

**USER CREATIVITY IN THE APPROPRIATION OF INFORMATION  
AND COMMUNICATION TECHNOLOGIES: A COGNITIVIST-  
ECOLOGICAL EXPLANATION FROM A CRITICAL REALIST  
PERSPECTIVE**

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by

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## Abstract

A fundamental process in many important research foci in information systems is the appropriation of IT artifacts in creative ways by users. The objective of this thesis is to develop a theoretical explanation of that process.

An embedded multiple-case study of incidents in which users, in a variety of field settings, developed creative ways to apply IT artifacts, was conducted. Employing theoretical lenses drawn from cognitive science (dual-process theory, distributed cognition), and Markus and Silver's (2008) variant of adaptive structuration theory, a novel theoretical framework was developed to analyze the data. This framework – Affordance Field Theory – was used to abstract away the context-specific details of each case, so that the events in each could be compared and analyzed using a common conceptual vocabulary.

Applying critical realist assumptions, the initial retroductive analysis was done with narrative networks, then the cases were re-analyzed using framework matrices. The complementary logical forms (processual and thematic, respectively) of the analytic tools helped to provide empirical corroboration of the findings. A set of cognitive mechanisms was identified that describe the information-processing operations involved in creative user appropriation. Using assumptions from distributed cognition, it was demonstrated that these mechanisms can describe those operations at the individual and collective levels. An integrative model which shows how the mechanisms explain user creativity at the individual level was then developed. It is called the Information Cycle Model of creativity.

This thesis makes several contributions to knowledge. It develops a theoretical framework for analyzing interactions between users and systems that is designed to represent the cycles of ideation and enactment through which creative appropriation moves are developed. It also presents a model of the cognitive mechanisms involved in the discovery of novel appropriation moves. The thesis also contributes to current debates within IS about representational metaphors for user interaction with IT.

*Keywords: Affordance Field Theory, Case Study Methodology, Creativity, Distributed Cognition, Dual-Process Theory, Information Cycle Model, IT Innovation*

## **Dedication**

In loving memory of my mother, Lorna Elaine Baker

Loved

Remembered

Longed for always

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# Chapter 1. Introduction

## 1.1 Introduction

*The secret to creativity is knowing how to hide your sources*

*Einstein (allegedly)*

Where is the research on creativity in the Information Systems (IS) discipline?

Creativity is a widely-cited topic of interest in the management disciplines in general (Kern, 2010), and IS in particular (Couger, 1988; Nambisan, Agarwal, & Tanniru, 1999). Nearly all of the papers in IS that look at creativity comment on the understudied nature of the topic (Aaen, 2008; Couger, Higgins, & McIntyre, 1993; Seidel, Müller-Wienbergen, & Becker, 2010), and the need for more research on creativity in the discipline. Yet, the volume of those papers, both comparatively and absolutely, is vanishingly small. One comprehensive review of the topic in the “basket of eight” highest-ranked IS journals between 1977 and 2009 found 27 papers, less than 0.5% of the total number of articles in the period (Seidel et al., 2010). Further, creativity is one of those interdisciplinary topics in which the IS discipline — one would think — is well-positioned to make substantial contributions. Yet, most IS researchers don’t seem to even make the attempt. Why?

These questions must be asked before embarking on a study of creativity in an IS context because it does appear anomalous that creativity has for so long escaped substantial theoretical scrutiny in the discipline. Explaining why so there is so little IS research, on what would seem like an important topic, may offer clues about what needs to be done. This is especially so in the case of this current study, which aims to understand and explain one particular type of IS-related creativity: how end users find and develop creative ways to modify, repurpose, combine, utilize — to *appropriate* — Information Technology (IT) systems. This is an important topic for its potential to maximize the returns that users and organizations that invest in IT are able to earn from those investments. IS researchers have pointed out that this application of user creativity can be an important source of competitive advantage (Hsieh & Zmud, 2006, p. 2), and can often lead to the users of IT systems unlocking more value than the developers of those systems realized were possible (Dutton & Thomas, 1984). It is therefore an area in which the answers to theoretical questions about behavior may lead to matters of immediate relevance to the practice community and the broader business world.

How great is the potential for generating excess value that can be unlocked through user creativity? Let us consider two real-life, illustrative vignettes:

### **1.1.1 Vignette I**

*In October 2006, a group of developers launched an HTML-based micro-blogging service, intended as a simple way for friends to send short messages to each other, à la SMS, over the internet. The developers saw the micro-blogging tool as “not that useful, but a fun thing for family and friends when they are not in the same place”. They named the service ‘Twitter’ after the definition: ‘a short burst of inconsequential information’. Users of the service could ‘follow’ other users and automatically see their tweets (messages), but anyone could see or search for any other user’s messages.*

*In 2007, a consultant named Chris Messina had an idea: perhaps groups could be formed on Twitter by creating a group name and preceding the name with a pound sign (#) in the message. That would mean that anyone who was interested in the group could simply search for #group\_name and see all messages regarding the group. The proposal, which Twitter co-founder Evan Williams dismissed as “too nerdy” to work, was implemented. This fundamentally changed the way the service could be used: instead of being able simply to follow people, users could now also follow topics. The Twitter micro-blogging service has gone on to become one of the most influential social networking companies on the internet. In 2008 alone it grew over 750 percent in unique visitors. Its availability has been named as a significant factor in the organizing of mass political protests, coordinating disaster relief and social marketing. In 2013 its market value soared to almost 25 billion USD.*

*One of the reasons for Twitter’s success is certainly the invention of the hash tag, which was done, not by the creators, developers and implementers of Twitter, but by an end user.*

(Bice, 2013; C. C. Miller, 2010; Ostrow, 2009; Popelka, 2013)

### **1.1.2 Vignette II**

*In Kenya, mobile phones were first introduced in the mid-1990s. By 2008, the penetration of cell phones had swelled to approximately 17 million, and cell phones had eclipsed landlines (use of which declined by 17% over the same period) as the primary means of telecommunication. Mobile phone companies introduced a feature that let people purchase air time with prepaid cards and transfer this to other users. This was originally intended as a convenience, so that people in urban areas who were close to shops could buy air time for their rural-based families, for instance. However, users began to use this feature as a proxy for money, exchanging air time with local brokers for both cash and goods.*

*In 2007, Safaricom, the largest mobile phone company in Kenya, started a service that formalized this informal transfer system and created a mobile financial service that allowed people to deposit, transfer*

*and withdraw funds from accounts with the service using their cell phones. The service spread rapidly and is now the largest and most successful mobile banking product in the world. The service, called M-Pesa (“M” for “mobile”, “Pesa” is Kiswahili for “money”), is used by about 40 % of Kenya’s population and has about 25% of the country’s GDP flow through it. It has been copied by mobile companies in a number of other countries.*

*All of this started, not with an idea by the mobile phone company itself, but with the repurposing of a feature by end users.*

(Jack & Suri, 2010; McKemey et al., 2003)

One common feature of the above accounts is that the innovations described, innovation which have led to substantial benefits for users and immense profits for the businesses which owned the platforms that were part of the innovations, emerged from ideas which did not originate in those businesses. Rather, they emerged from ideas which originated with end users. The phenomenon of the users of products finding innovative and valuable ways to apply those products has been well noted in earlier research in a number of contexts (Flowers, von Hippel, de Jong, & Sinozic, 2010; Oliveira & von Hippel, 2011; Von Hippel, 1976, 1986, 2005). In a number of domains users have developed novel, useful and valuable ways to repurpose – with or without modification – existing products in ways that extend their functionality. Often, these user innovations have been subsequently adopted by the companies that developed the base products, leading to new market opportunities.

The type of innovation being described involves users finding ways to use systems that are novel, useful, and appropriate for a purpose; that is, they meet several widely-accepted definitions of creativity (Amabile, 1996; Csikszentmihalyi, 1997, 1999b; Hennessey & Amabile, 1998; Stein, 1953). Creativity has been widely explored in a number of the management and behavioral sciences (Wehner, Csikszentmihalyi, & Magyari-Beck, 1991), but very little has been done within IS. Further, the work that has been done in IS has focused largely on creativity on the part of system developers and implementers, as well as the creative performance of the users of system features designed to support ideation, rather than the discovery of creative ways of using the system.

This thesis is aimed at filling that gap in the literature by exploring the creative process by which users discover new and useful ways to use systems.

## 1.2 Research Approach

There are several existing theories which describe both the processes and antecedents of creative action. One of those theories – the Componential Theory of Creativity proposed by Amabile (Amabile, 1988, 1996) – will be used to form an initial conceptual model for this study. I will make the case that the behavior being studied – the reuse or repurposing of an existing IS in order to use it in a creative way – is best described as an *appropriation* process, as defined by (DeSanctis & Poole, 1994; Poole & DeSanctis, 1989). The method for building theory from case study research developed by Eisenhardt (1989) will then be applied to explain creative appropriation. One initial question that should be addressed is that of why a theory to explain creative appropriation is necessary. If there are several existing theories for explaining creative behavior, why not apply one? Or test several and find which one provides a “best fit” for the phenomenon?

I propose that developing a theory to explain creative appropriation is necessary for two reasons. One is the unique nature of theory in the information systems discipline. Gregor (2006) points out that the domain of interest of a theory can be expected to influence its nature. The domain of Information Systems (IS) is unique in that it is concerned with the use of a special class of tool by users in human-machine systems and the emergent phenomena that emerge as a consequence of that use. It follows that a theory of creativity that describes how people use IT systems creatively may be ontologically distinct from theories of creativity that have been developed to describe creative behavior in other domains (Dreyfus, 2009).

The second reason why a theory of creative appropriation should be developed is related to the first and has to do with the motivation and goals of the creative actor. There are a number of existing theories that describe the creative process, the factors that influence creativity, or both. For example:

- Wallas (1926) proposed four stages: Preparation, Incubation, Illumination, and Verification
- C. M. Ford (1996) proposed a theory of individual creativity incorporating: Sensemaking, Motivation, and Knowledge and Ability
- Woodman, Sawyer, and Griffin (1993) proposed that individual creativity is a function of: Antecedent Conditions, Personality Factors, Cognitive Factors, Motivation, Social Influences and Relevant Knowledge
- Amabile (1983) proposed that, at the individual level, the factors of Domain-Related Skills, Creativity-Related Skills and Task Motivation influence creativity through the stages of Problem Presentation, Preparation, Response Generation and Response Validation

A common feature of these theories is that the outcome – the creative product, response or action – and the goal of the creative actor are one and the same. The literature on rationality distinguishes primary goals and derived goals (Stanovich, 1999, p. 16). In most existing models of creativity, the creative process is analyzed where the creative output is the primary goal of the creative actor. In contrast, the creative

appropriation of an information system is typically a derived goal. For example, a ‘creative’ painter paints in order to produce creative paintings. Her motivation is to maximize the creativity of the output produced by the process of painting. The use of an IT system, in contrast, is a goal-seeking behavior (Burton-Jones & Straub, 2006). The goal of a user creatively appropriating an IT system is (typically) not to develop a creative way to use the system, but accomplish a task; and developing a creative way to use the system is a means to complete that task, rather than an end in itself. The user of an IT system will typically be “employing one or more features of a system to perform a task” (Burton-Jones & Straub, 2006, p. 231). Her motivation will typically be related to the task being performed rather than the interaction with the system. One possible exception to this rule – interaction with hedonic systems such as games – is outside the scope of this present project. It is possible that a system may be used creatively as a stage in the production of an outcome or response which is not, itself, creative. The creative appropriation of an existing IT artifact relates to creativity in a goal-seeking behavior, rather than the creativity of the goal-state outcome. This is particularly worthy of exploration given the central role of motivation in creative performance postulated by Amabile (1996, pp. 107, 115).

An exploratory theory-building approach will therefore be used in this research. The approach used will be the method for building theory from case study research proposed by Eisenhardt (1989a). Below, I introduce the two fundamental concepts that underlie the topic being studied: creativity and appropriation.

### **1.2.1 Creativity: Open Questions**

An unusual type of creativity is still a type of creativity. While creative appropriation may differ structurally in some ways from the more common contexts in which creativity is studied, it does still relate to some of the deep questions about creativity that have long been debated.

One of the longest-standing questions about creativity has to do with its locus: is it best seen as an individual trait, or something which emerges from the environment? The view with which this question is approached has tended to change over time. In 1950, Guilford (1950, p. 444), in his inaugural address as president of the American Psychological Association said “In its narrow sense, creativity refers to the abilities that are most characteristic of creative people”. This reflects the approach that holds that individual qualities are the cause of the creativity, and creativity research should proceed by attempting to measure those qualities. However more recent research has strongly supported the hypothesis that creativity emerges from certain contextual conditions, particularly group and network effects (R. K. Sawyer, 2007; Uzzi & Spiro, 2005). Where does the source of creativity lie?

One of the ways to address this question is to look at the phenomenon of multiple creative discoveries or products being made simultaneously by unconnected individuals. If creativity is primarily dependent on individual traits, we would expect such occurrences to be rare. If, however, creativity is primarily

influenced by environment, we would expect that there would be several instances where different individuals exposed to similar environments would generate similar creative products. There is evidence for the latter case on one well-documented area of creativity: that of scientific discovery. The phenomenon of the same discovery being made within the same timeframe by different scientists is surprisingly common. Merton (1961) famously discussed this pattern, labeling discoveries that were made by a single individual scientist as “singletons” and discoveries by more than one scientist simultaneously as “multiples”. He proposed the hypothesis that “all scientific discoveries are in principle multiples, including those that on the surface appear to be singletons.” Merton (1961) also notes that Ogburn and Thomas (1922) pointed out this pattern early in the century. Merton also pointed out that the principle of multiple discovery has itself been discovered multiple times, citing over 18 occasions when the principle was ‘re-discovered’ in recent history, often by several individuals at once. This phenomenon, has been noted in a number of contexts and disciplines (D. H. Ford, 1987), and has been extensively cited in debates on how intellectual property rights should be protected (Lemley, 2011).

It seems unlikely that such a pattern could exist unless the source of creativity is independent of the individual. Obviously there must be some environmental explanation to account for multiple, unconnected individuals making the same discovery at the same time. However, the story is more complex than it may appear at first. While there may be incidents of multiple discovery, there is also a parallel observation that must be made. There are individuals in history who have been associated with significant creative achievements multiple times in their lives: persons like da Vinci, Edison, Tesla, as well as more contemporary figures like Jobs and Musk. If the sources of creativity lie in the environment, why is it that some individuals are able to be “creative”, even in different environments and contexts across their lives? To put it bluntly, these people are good at *something*, what is it?

Modern creativity researchers are increasingly accepting of the fact that there can be no single answer to the question of “what causes creativity?” Creativity appears to emerge from a combination of inputs at different levels (Runco, 2004). But what are these inputs? How are they combined? Is it even meaningful to treat “creativity” as a single thing across diverse domains? Most pertinently for this study: do these things differ in their nature, their effects, and their implications, between incidents of creativity where the actors involved are pursuing primary or derived goals?

These are, largely, open questions which are still matters of debate in the creativity literature. This thesis may not settle them, but it will take a position and contribute to that debate.

### **1.2.2 IT Appropriation**

One of the most fundamental processes in IS is the interaction of human actors with IT systems (Gregor, 2006). This interaction often takes the form of a human interacting with a system, or systems, in order to pursue a goal (Burton-Jones & Straub, 2006). IT systems are artifacts: they are constructed by humans,

and they typically are constructed in a particular way — designed — in order to perform some function. The design of IT artifacts often begins with a mental picture of a particular user's goals, and the artifact is designed to meet those goals. However, in the real world, there are often gaps between the modeled goals of designers and the actual goals of users. How can users make use of systems if those systems do not fully or accurately reflect their use intentions?

In order to explore this question in the context of systems for facilitating group decision-making DeSanctis and Poole (1994) used the concept of *Appropriation*. Appropriation was developed in the work of Marx and Hegel (Poole & DeSanctis, 1989), and is described as the mutually constitutive process by which use of a tool could define both the user and the tool. The concept was applied to Group Decision Support Systems (GDSS) because of the variety of ways in which the same features of a GDSS could lead to different outcomes, depending on how those features were used. Appropriation can also apply to many modern systems which are multifunctional and can be applied in different ways. A typical modern mobile phone may be capable of being used as a camera, GPS unit, calendar, email client, news portal, etc. Its identity — what it is — is largely decided by the way in which a particular user decides to use its capabilities. The same phone, with the same installed features and software, may *be*, in the hands of one user, a mobile telephone; and in the hands of another user *be* something completely different.

In this study, the appropriation concept will be used to describe the process by which users find ways to use systems that are both novel and useful, that is, creative.

### **1.3 Research Objectives**

This study aims to develop a theoretical explanation of the phenomenon of end users discovering or developing novel and useful ways to use IT systems.

In this section, I will define some of the key terms that I will be applying throughout the thesis. I will then specifically lay out the goals of the research and state my research question.

#### **1.3.1 Definitions**

This study aims to theoretically describe the creative process by which users repurpose, recombine or reconfigure information systems in ways which are novel and useful: ways which would probably surprise the developers of those systems. It is worthwhile at this point to provide a few definitions for some key terms which will be used in the study.

*Users*

Users are social actors who employ IT systems in a task (Burton-Jones & Straub, 2006). Unless specified, for this thesis the general concept of *user* can be applied to either individuals or collectives (Markus & Silver, 2008).

### *IT Systems*

IT systems are defined here as artifacts which provide representations of task domains (Burton-Jones & Straub, 2006). They can be regarded, in part, as instantiations of mental models of task domains on the part of designers (Hevner, March, Park, & Ram, 2004). However, they are also shaped by interaction effects, chance, and the choices of users (Germonprez, Hovorka, & Gal, 2011), and so are never complete reflections of any single mental model.

### *Creative*

There are a number of definitions of creativity. In this thesis I will apply a product definition, in which “creativity” is judged by a rating of its output (Rhodes, 1961). A product is considered creative if it is novel, useful and appropriate for a purpose (Amabile, 1996; Stein, 1953).

### *Tasks*

Tasks are goal-directed activities performed by users. For this thesis, I will concentrate solely on tasks which are business-process related, rather than hedonic (Van der Heijden, 2004).

### *Use*

For the initial discussion, I will follow Burton-Jones and Straub (2006, p. 231) and define “use” as a “user’s employment of a system to perform a task”. Later in the thesis, I will adopt a more appropriate lens for discussing the specific type of use in which systems are repurposed creatively – that of appropriation.

Some further discussion of two of the above definitions is warranted. The definitions above refer to “users” and “designers” of IT systems. It has been proposed that the distinction between users and designers of systems must be reconsidered, and that users should more accurately be considered as co-creators of systems when their use choices help to define and redefine what those systems are. For example, in the vignettes considered earlier in this chapter, the actions of the “users” were an integral part of the creation of the current form of the systems that they “used”. Is there any reason why they should not be recognized as designers? This question has been considered in the work of IS theorists such as Germonprez et al. (2011), and in contexts beyond IS (Von Hippel, 1986, 2005).

There is little support for a hard-and-fast distinction between users and designers. In many contexts, users can usefully be seen as co-designers. Also, designers of one system will often be users of another,

and vice versa. However, within the context of any single study, there are likely to be persons who interact with IT systems in different roles. One role might be to develop a model of a task domain and build a technological artifact that models that task domain in a way that enables goal-seeking interactions. We may consider persons in that role to be *designers*, in the context of that study. Another role might be to appropriate (or use) a technological artifact in order to accomplish a task-oriented goal. We may consider persons in that role to be *users*, in the context of that study. There is therefore an argument for a context-specific distinction between users and designers based on role, rather than identity.

As such, in this study, “users” and “designers” will be identified by role. Any person who employs an IT system to perform a task (Burton-Jones & Straub, 2006), whether or not that person is an IT professional, will be considered a “user” *of that system* in the context of this study. Where a user appropriates a system in a manner that is creative, the result may sometimes be seen as a new “system”, further blurring the distinction between users and designers. For this study, therefore, the designation of “designer” will be used for the person who builds the base system – i.e., the system being appropriated – rather than the system resulting from the act of appropriation.

### 1.3.2 Research Goals

The goal of this project is to provide a theoretical explanation of how users find novel and useful ways – ways that are rated as “creative” – to use systems. As will be described in the following chapter, there has been little study of creativity as a topic in the information systems discipline. What little study has been done has tended to look at creativity on the part of system developers, implementers, and the users of creativity-facilitation systems (see Seidel et al., 2010). There has been little focus on the creativity of users in finding novel and useful ways to use systems.

The goal of the thesis is *explanation*. Explanation is a common goal for certain types of theoretical studies (Gregor, 2006), but has seldom been discussed in depth in the IS literature (Hovorka, Germonprez, & Larsen, 2008). I will develop a mechanism-based explanation of the phenomena of creative user appropriation (Hedström & Ylikoski, 2010). This type of explanation is fundamentally causal, it details the “cogs and wheels” of the causal process by which the phenomenon of interest came to be (Hedström & Ylikoski, 2010, p. 50).

There are numerous hypotheses regarding the determinants of creativity. Attempts to explain creativity have looked at a range of factors, from neurological processes within the brain (Takeuchi et al., 2011) to societal-level mechanisms (Hirschman, 1967). In order to scope the thesis, I will limit my goal to the explanation of user creativity in the appropriation of information systems at the individual level. An explanation of creativity limited to the individual level is somewhat artificial: people and their contexts interact to produce behaviors and actions. As such, the theory developed in this thesis will only tell part of the story. Within the web of environmental influences, contextual conditions and social interactions that

are part of a typical creative incident, there will be individual actors. The theory developed in this thesis will explain – at an appropriate level of abstraction – the actions of those individual actors.

It must be noted that while the theory being developed seeks to explain creativity at the individual level, it is impossible to describe and analyze individual behavior without consideration of the context within which that behavior takes place. I will therefore need to have a conceptual language which can describe that context. The development of this conceptual language is one of the contributions of this thesis and it will be described in Chapter 6.

### **1.3.3 Research Question**

This thesis will describe an embedded multiple-case study that was conducted in ten companies across three cities in New Zealand between May 2012 and July 2013. This study followed the “roadmap” for inductively developing theory from data developed by Eisenhardt (1989a). In this roadmap, initial definition of constructs to be measured, and initial research questions, are important, but also tentative (Eisenhardt, 1989a, p. 536). Research questions, initial constructs, and even research focus, often need to be modified in response to preliminary findings that emerge during data collection (Eisenhardt, 1989a, p. 536), and the framework is designed to accommodate such modifications. In this study, several modifications were made in response to emerging findings during data collection. The most important of these was a change in explanatory strategy, which prompted a change in the form of theory being developed, and the adoption of new metatheoretical assumptions. These led to a significant transformation of the research questions.

Initially, constructs were drawn from the work of Amabile (1982, 1983, 1988, 1996). The initial research goal was to find a set of factors which were related to end user creativity, observe how these factors contributed to the creative process, and construct a synthetic variance model (Langley, 1999), adapting the strategy followed by Amabile in her own work on creativity. Early findings in the data showed weaknesses in the explanatory power of this strategy. The form of the theoretic explanation being constructed was therefore changed from a synthetic variance model to a mechanism-based strategy. Mechanism-based explanations are common in the physical and biological sciences (Bechtel, 2005), and are gaining popularity in the social and behavioral sciences (Hedström & Ylikoski, 2010) as well as integrative disciplines such as IS (Avgerou, 2013). Mechanisms expose the “cogs and wheels” (Hedström & Ylikoski, 2010, p. 50) of the causal processes behind observed phenomena, and are a suitable form of theory for explaining creative processes (Boden, 2004).

Along with the adoption of the mechanism-based strategy, I adopted critical realist assumptions. Critical realism is a philosophy of science which is commonly attributed to the writings of Bhaskar (1975), but has also been significantly developed by authors such as Sayer (1992, 2000) and Danermark, Ekstrom, Jakobsen, and Karlsson (2002). It has been explicitly recommended by a number of IS theorists as being a

particularly appropriate perspective for the investigation of phenomena in the discipline (Dobson, 2001; Markus & Silver, 2008; Mingers, 2004b; Morton, 2006). Critical realism was chosen because it provides a strong ontological foundation for research, and because it has the mechanism-based perspective at its core.

One implication of critical realism, especially in case-based explanatory research, is that a particular form of research question is required (Wynn & Williams, 2012, p. 804). Research questions that investigate a phenomenon must take the form “What caused the events associated with the phenomenon to occur?” (Easton, 2010, p. 122); or more formally “What mechanism must exist for the observed event to occur?” (Wynn & Williams, 2012, p. 799). Critical realism holds that mechanisms are typically not directly observable, and so the core of a critical realist analysis is to analyze observed reality in order to abductively derive the mechanisms which explain what was observed. Critical realism is more fully explored in a later chapter.

In keeping with the critical realist assumptions being applied in the research, the initial set of research questions were dropped, and a single research question introduced in their place. It is:

*What are the mechanisms that explain end user creativity in the appropriation of Information Systems at the individual level?*

## **1.4 The Rest of This Document**

The rest of this thesis is organized as follows.

In Chapter 2, I will review the literature on the use of systems in the IS discipline. In the course of doing so, I will propose an explanation for the dearth of research on creativity within the discipline. I will then go on to review the literature on creativity, looking at how it has been conceptualized in prior research, and laying a foundation for the approach that will be followed in the thesis. I will then review the literature on cognitive science, which will provide a number of critical theoretical lenses for the research.

In Chapter 3, I will review the literature on critical realism, and discuss the rationale for choosing this metatheoretical perspective for the research.

In Chapter 4, I will provide an overview of the design of the research project, and describe how unexpected findings in early data collection helped to shape the final approach that was taken.

In Chapter 5, I will describe the case studies that provided the data which was analyzed in this project. I will also describe the initial observations in the data which led to the adoption of modifications to the research design.

In Chapter 6, I will describe the data analysis which was conducted. This falls into two parts: the development of a theoretical framework for analyzing the data, and the retroductive and corroborative analysis of the data, using that framework.

In Chapter 7, I describe the cognitive mechanisms that were identified and described through the analysis of the data. I show how they are supported by the data, and the cognitive literature.

In Chapter 8, I discuss the implications of the identified mechanisms for current and future research. I show how they integrate with existing knowledge in the domains that they draw on, and suggest areas of inquiry for future work that they open up.

In Chapter 9, I review the thesis as a whole. I look at how the findings address some of the long-standing questions identified in this chapter, and list the contributions and limitations of the work, as well as the possibilities for future work opened up by the theory.

## **Chapter 2. Research Background**

### **2.1 Introduction**

A recurring theme in reviews of the literature on creativity in IS is the dearth of research on creativity in IS, and the fact that what research there is on creativity tends to be lacking in theoretical depth (Couger et al., 1993; Seidel et al., 2010). Surveys of C-level executives in major firms have identified creativity as the number-one quality they desire in their organizations (Kern, 2010; Lavalle, Hopkins, Lesser, Shockley, & Kruschwitz, 2010). This is also a priority for Information Systems (hereafter, IS) practitioners. In a Delphi study of IS Directors, Couger (1988) found that “Emphasize creativity and innovation” was one of the top ten human resource issues on their list of concerns. However, despite sporadic calls for further creativity research in the literature over the intervening decades, little actual creativity work has been done (Seidel et al., 2010). A fundamental question, and one which, ideally, should be addressed in any serious project to look at creativity in an IS context, is why this is so. There has been a great deal of creativity research done in several of the reference disciplines which IS draws on (Wehner et al., 1991), many calls have been made for more research on creativity in the discipline (Couger et al., 1993), it has been emphasized that contemporary research on system use in IS must enhance understanding of how users can apply systems creatively (Hsieh & Zmud, 2006); yet the state of creativity research in IS remains, as it was put by Couger et al. (1993): “embryonic”. Why?

In this chapter I will explore, and propose an answer, to this question. I will begin by looking at the history of the IS discipline, with a particular focus on the history of research into the appropriation of information systems by end users for utilitarian purposes: what has been referred to in the literature using terms such as “utilization”, “use”, “appropriation”, “imbrication”, and others. I will look at the history of research into how systems are used, and at how this research parallels developments in the metatheoretical assumptions used in IS. I will propose an answer to the “why” question above that is rooted in the assumptions that are part of the discipline’s history.

I will then go on to look more deeply at the topic of creativity itself. Creativity research has a long and rich history, some of which intersects with some of the same issues in the philosophy of science that have shaped IS research. I will briefly explore the history creativity research, and will take a closer look at some of the contemporary approaches to the conceptualization and measurement of creativity that will have a direct influence on this thesis. I will then look at the discipline of cognitive science, the interdisciplinary study of the working of the mind, which will provide several key theoretical lenses and perspectives that will be applied in this study.

Having reviewed the literature in these three areas, I will discuss the implications of the different perspectives for the current project. I will list and explain the major theoretical lenses that have been selected for this project. These selections took place at different points in the unfolding of the project. For example, it was necessary to begin the project with a priori definitions of utilization and creativity. However, as will be described in the chapter on research design, the emergence of cognitive science as an appropriate lens for explaining user creativity emerged only after initial rounds of data collection and analysis. However, all the key literature will be reviewed in this chapter.

I therefore begin with a look at how people interact with information technology systems for the purpose of completing utilitarian tasks.

## **2.2 IS and System Utilization**

System use is one of the most venerable constructs in the IS discipline (Barkin Gary & Stephen, 1977; McLean, 1979; Schewe, 1976), and high levels of it is one of the most widely accepted proxies for IT implementation success (DeLone & McLean, 1992, 2003). It is one of the most commonly-measured variables in quantitative IS research (Burton-Jones & Straub, 2006), and its effective measurement has been proposed as the ‘missing link’ in attempts to model the effects of IT on firm performance (Beaudry & Pinsonneault, 2005; Kohli & Devaraj, 2003). Moreover, it is a commonly-cited fact that information systems cannot generate value unless they are used (Collan & Tetard, 2007; Furneaux & Wade, 2011; Orlikowski, 2000, p. 425). The use of IT artifacts is a fundamental focus of IS research (Gregor, 2006, p. 613), and so, almost all empirical and conceptual IS research has the utilization of IT systems at its core. Olbrich, Muller, and Niederman (2011) call IS “an integration discipline at the intersection of social and technological phenomena” (2011, p. 6), an intersection that is nowhere more explicit than when users use systems.

One question which ought to be addressed early is what is meant by “systems”. There are now a large number of artifacts which have attributes once exclusively associated with computers — such as microprocessors and programmability — but also have features and functionality long associated with objects other than computers. Microprocessor-equipped cars, watches, clothing, cooking devices and wearable accessories have blurred the boundaries between computational and “other” devices. I will adopt a definition from Pentland and Feldman (2007) which provides the following characteristics for identifying an “IS” for the purposes of this study:

- *Modular* - they consist of small modules or components which can be decomposed (see also Markus & Silver, 2008)
- *Recombinable* - “Substitution and recombinations multiply the possible storylines for accomplishing tasks” (Pentland & Feldman, 2007, p. 784). Being modular they can often be recombined in different ways

- *Distributed* - Refers to the fact that ICTs can allow people, tools and tasks to be separated by both time and space. A fundamental difference between ICTs and other classes of tools.
- *Communicative* - ICTs are naturally in the domain of semiotic engineering. Even an office productivity system, which may not have explicit communication features, can be used as a communication tool by being employed as a shared symbol system
- *Memory* - “inscription”, all but the simplest can store and retrieve information.

Burton-Jones (2005) notes the diversity of forms that measures of system use have taken in prior research: forms such as indicators (e.g. use/nonuse (F. D. Davis, 1989)), frequencies (S. Taylor & Todd, 1995a), assessments (Boudreau & Seligman, 2003) and evaluations (Auer, 1998). However, he also notes an anomaly: system use itself, while frequently measured as an outcome or proxy, for a long time evaded serious scrutiny as a theoretical construct (Burton-Jones, 2005, p. 2). For example, Trice and Treacy (1988) found only 17 articles examining ‘utilization’ over the period 1975-1985. In the past few years, however, there has been a surge of interest in system use as a research topic. There has been a robust debate about what it means, how it should be conceptualized, and how it should be measured and interpreted (see for example, (Barki, Titah, & Boffo, 2007; Burton-Jones & Straub, 2006; McLean, Sedera, & Tan, 2011; Orlikowski & Scott, 2008)). While there are a number of competing positions on each of those dimensions, it is useful to consider the drivers behind the debate: why is it that authors have been expending so much time and energy on utilization? Why have so many scholars been developing or proposing novel methods of representing utilization in research? And, given the very modest response to calls for such research in the past, why now?

In part, it may be because of the repeated calls for a deeper consideration of how utilization is conceptualized and measured (DeLone & McLean, 1992; Seddon, 1997; Straub, Limayem, & Karahanna-Evaristo, 1995). However, I contend that there is another driver, as well. IS emerged as a recognizable discipline in the late 1950s to mid-1960s (G. B. Davis, 2000; Hirschheim & Klein, 2012). Its actual genesis point may be ambiguous, but it has been posited to be the article by Leavitt and Whisler (1958), in which they coined the term “information technology” (see (Culnan, 1986; Markus & Robey, 1988)). When the field was in its infancy, the main function of an IT system in a business context was “the automation of clerical tasks” (Hirschheim & Klein, 2012, p. 203). While the nature and role of IS utilization has expanded greatly in the intervening years, until very recently the implicit conceptualizations of system use applied in extensive quantitative research have been better suited to the measurement of clerical output — frequencies, amounts, use/nonuse dichotomies, durations, etc. — than the much richer meanings of utilization that are now appropriate (Burton-Jones & Straub, 2006, p. 229). In intensive research, meanwhile, research has focused on rich explication of the context and nature of use, but has often done so in a manner which does not facilitate cross-study assimilation and accumulation of knowledge (Benbasat & Zmud, 1999). The challenges created by this state of affairs have not gone unnoticed in past

IS research, but it appears to have reached the point where it is precipitating a fundamental shift in the discipline.

Perhaps the most well-known of the current wave of treatments of utilization has been that of Burton-Jones and Straub (2006), who looked at the ontological structure of the system use construct and proposed a definition and measurement procedure based on that structure. However, there have been a number of other notable contributions to the literature on system use in recent years, including (Burton-Jones & Gallivan, 2007; Burton-Jones & Grange, 2012; Burton-Jones & Hubona, 2005; Gerpott, 2011; Grgecic & Rosenkranz, 2010, 2011; McLean et al., 2011; Sedera & Chian, 2007). In addition to the increasing interest in system use as a construct, there have also been a number of papers which propose new metaphors for representing the interaction between end users and information technology artifacts, such as behavioral design (Germonprez et al., 2011), sociomateriality (Orlikowski, 2007), and imbrication (Leonardi, 2011). One possible source of the many and diverse conceptualizations of use in the literature is the etymological complexity of the term. The word ‘use’ originated in the early 13 century from the Latin words *usus* (noun form), meaning “use, custom, skill, habit”, and *usare* (verb form), meaning “use, employ, practice” (Harper, 2011). According to the Merriam-Webster College Dictionary, the word “use” may take any of eight meanings, four as a noun and four as a verb, and has multiple synonyms (Merriam-Webster, 2003). It is little wonder that the concept of “use” in IS research has been called “deceptively simple” (Zigurs, 1993). This deceptive simplicity has inevitably led to problems of specification in discussions of use in previous studies. As an example, DeLone and McLean (1992)’s paper on IS success makes the concept “IS Use” central to their model of IS Success. However Seddon (1997) pointed out that there are multiple possible meanings of the phrase “IS Use” in the DeLone-McLean model, and thus multiple possible meanings of the model.

I will attempt to avoid ambiguity by starting this section with definitions of the key concepts I will be applying in it (Webster & Watson, 2002). The review will look at how IS researchers conceptualize and measure the ways in which end users use IT systems. However, the term “system use” has been frequently used when discussing the system use construct in nomothetic quantitative research (Burton-Jones & Straub, 2006; DeLone & McLean, 2003; McLean et al., 2011). Because this review will look at different types of conceptualizations of use, I will use another term which was common in older research but is now applied less frequently: *system utilization* (see (Barkin & Stephen, 1977; Trice & Treacy, 1988)). The term “system use” will be reserved for speaking about the use construct in quantitative research. Also, like Hirschheim and Klein (2012), I use the terms *discipline* and *field* interchangeably: to describe a defined, named academic domain which has a recognized identity.

Given the centrality of the utilization of IS to the major domains of interest within the discipline (Gregor, 2006), there is very little research in the field that is not somehow related to the topic. A review of the study of system utilization in IS must therefore be very specifically scoped. If not, it could easily become a

review of the history of the IS discipline itself. This would be redundant, given the fact that the history of the IS discipline has been well reviewed by Dickson (1981), and Hirschheim and Klein (2012). In this section, therefore, I will focus on the aspect of IS utilization that is of primary importance to this thesis: the dominant methods of conceptualization and measurement that have been applied in IS, and the way they have enabled and constrained the exploration of some research domains in the discipline.

### 2.2.1 Background

The way in which phenomena are conceptualized, operationalized, and measured within a discipline are highly dependent on the metatheoretical assumptions which prevail in that discipline. For much of the history of IS, a single metatheoretical position was so dominant in the field that discussion about metatheory was limited, or nonexistent (Hirschheim & Klein, 2012, p. 204). In the current state of the field multiple metatheoretical approaches are accepted, and debate about the merits of different positions is common. There are two current mainstream metatheoretic positions in IS research: the *positivist* and *interpretivist* positions. While there are a number of competing positions (and this thesis will adopt one of them), these two positions represent the vast majority of the published research in IS's most influential journals over the past 40+ years. Positivist and interpretivist approaches have substantially different ontological, epistemological, methodological and axiological assumptions (Fitzgerald & Howcroft, 1998). In many ways, they inhabit opposing ends on a number of continua in terms of basic beliefs. The merits of each of these positions and the suitability of each for use in the addressing of different problems in IS has been extensively debated (W. Chen & Hirschheim, 2004; A. S. Lee, 1991; Nandhakumar & Jones, 1997; Orlikowski & Baroudi, 1991; Walsham, 1995a). This section will not attempt to argue for either position, but will rather attempt to explain the way that each has influenced debates in IS about research and how it should be conducted.

Before beginning this discussion, however, it is important to acknowledge that the terms in which this discussion is being framed – positivism vs. interpretivism – are inherently flawed. Moldoveanu and Baum (2002) have argued that positivism ceased to be a coherent philosophical position with Berlin's refutation of Ayer (1936) and Church's refutation of Ayer (1959) (see Hacking, 1975 for a fuller discussion). Manicas (1987) lists a series of 11 events that occurred in the twentieth century which together mark the overturning of the classical positivist view of reality. Despite this, many scientists, including many within IS, continue to identify themselves as positivist. Moldoveanu and Baum (2002) argue that this is because they misattribute their own assumptions as positivist, when in fact they are metaphysical realists and methodological empiricists (Moldoveanu & Baum, 2002, p. 737). They propose that most, if not all, active scientists who self-identify as positivists are, in fact, realists of some sort. As for interpretivism, it is widely acknowledged that interpretivism is not one thing, and that there are many related-but-distinct philosophies which coexist under the label of "interpretivism" (H. K. Klein, 2004; Mingers, 2006; Walsham, 1995a). Indeed, the constructionist assumptions the underlie interpretivism

would seem to imply that there can never be a single version of interpretivism (Moldoveanu & Baum, 2002). However, these terms – positivist and interpretivist – are widely used in the IS literature (A. S. Lee, 1991; Walsham, 1995a; R. Weber, 2004), and there is a broad shared understanding of the research traditions that they represent within the field. These common understandings will be drawn on to frame the discussion.

Identifying the different positions occupied by various researchers and identified by different studies can be challenging – at times, even for the researchers themselves. For example, Eisenhardt (1989a), discussing the roadmap that she developed for inductively developing theories from case studies, refers to it as “positivist” (Eisenhardt, 1989a, p. 546). However, elsewhere, she refers to her work on decision-making in high velocity organizations – during which she developed her roadmap – as “interpretive” (Bourgeois III & Eisenhardt, 1988b, p. 820). I will be guided by the very influential framework for classifying studies proposed by Orlikowski and Baroudi (1991), which has been widely adopted in subsequent work (see (W. Chen & Hirschheim, 2004; Walsham, 1995a)).

### **2.2.1.1 Positivism/Empiricism**

The metatheoretical approach known as “positivism” is a philosophy of science that is a subtype of *empiricism* – a philosophical position that holds that all scientific knowledge should be based solely on value-free empirical observation (Mingers, 2006). Positivism is *realist*, in that it posits the existence of a reality that is external to the researcher and would exist whether it was perceived or not. Positivism also holds that researchers are able to observe and measure this reality objectively and reliably. Positivism also holds that events in the world occur in regular patterns which can be observed and measured by researchers. Observation of these patterns enable researchers to derive general laws about the nature of reality, laws that enable them to make predictions about future events. It is important to note that these laws can be probabilistic in nature. The fundamental purpose of science, for positivists, is the discovery and description of these causal laws – typically in the language of mathematics or formal logic – in such a way as to enable the accurate prediction of future events. This is done using methodologies based on foundations such as Hempel (1965)’s deductive-nomological model (Danermark et al., 2002, p. 7). Positivist approaches are normally associated with deterministic assumptions, the variance form of theory (Mohr, 1982), cross-sectional designs, and the use of quantitative data and analysis. Whereas most reviewers within IS have found that positivist research tends to fit this typical profile (see, for example, Orlikowski & Baroudi, 1991), it should also be noted that intensive (Dubé & Paré, 2003) and process (Abbott, 1992) approaches are also compatible with positivist assumptions (Sabherwal & Robey, 1995). Positivist approaches to research are reflected in concepts such as Danermark et al. (2002)’s Foundationalism; Mingers (2006)’s Empiricism; and Orlikowski and Scott (2008)’s Research Stream I.

Modern positivism has its roots in the work of a group of philosophers at the University of Vienna in the 1920s. The so -called “Vienna Circle” developed a perspective that they defined as *logical positivism* (or

*logical empiricism*), largely in response to, and in repudiation of, the then-dominant metaphysical approaches to studying reality. According to Mingers (2006), logical positivism held to three basic tenets about the nature of scientific knowledge.

- Science (in order to be recognizable as “genuine” science) must be based on what can be empirically experienced.
- Knowledge about the world should be expressible in the language of mathematics
- All knowledge about both the natural and social domains should be acquired using common principles and expressible using a common symbol system.

In context, the positions of the logical positivists should be seen as, in part, a reaction against metaphysics, as much as an attempt to develop a set of epistemological principles for research (see (Neurath, 1931), (Goulding, 2002)). These principles, and the underlying assumptions on which they were based, did not go for very long before being challenged, and, ultimately, rejected. Psychologists, sociologists and philosophers refuted the assumption that there could be such a thing as objective, unbiased observation by social scientists, demonstrating that all observation was theory-dependent (Mingers, 2006, pp. 15-16). Interestingly, findings in the natural sciences had led to similar conclusions in the non-social domain (Heisenberg, 1927). Manicas points out that, in the social sciences, every key tenet of positivism – as so defined by the Vienna philosophers – has been discredited, and rejected (Manicas, 1987, p. 243).

This does not, however, mean that positivism has ceased to be a central model for the conduct of research. In IS research, for example, many surveys of the literature have established that positivism is the dominant form of metatheory that underlies much published research, both contemporary and historical (Hirschheim & Klein, 2012; Nandhakumar & Jones, 1997; Orlikowski & Baroudi, 1991). The question may be asked, how does positivism remain the dominant metatheoretical model despite the fact that its fundamental assumptions have been empirically disproved? The answer, according to Manicas (1987, p. 244), is that although logical positivism as a whole has been thoroughly rejected – to the point where virtually no serious practicing scientist holds to Vienna Circle logical positivism – it is easy to pick and choose among its elements. Various schools of positivism now exist in which the basic empiricist principles of the original version of positivism form part of the foundation, but specific weaknesses or criticisms of the position are taken into account or compensated for. These reformulated versions of positivism, in which the basic realist and epistemological assumptions of positivism are tempered, but kept intact, are collectively labeled “post-positivist” (H. K. Klein, 2004). Modern research that is labeled as “positivist” almost invariably is actually post-positivist in orientation. However, these post-positivist orientations have been critiqued as offering a “weak empiricist” position that leads to an “impoverished” view of realist ontology and causality (Mingers, 2004c, p. 88).

### **2.2.1.2 Interpretivism/Constructivism**

There are, however, other metatheoretical positions that offer other views of the world that are distinct from the empiricist view. Perhaps the most influential of these – particularly in IS and social research – is the *interpretivist* perspective. The label of “interpretivism” covers a wide range of approaches (Mingers, 2004a, p. 150), which share a number of common features. Interpretivism is fundamentally *relativist*: that is, it holds that all knowledge is subject-dependent – that is, relative – to the observer. It holds that knowledge of reality is a social construction, driven by the preconceptions, biases, and orientations of the knower. Therefore, it is impossible to have value-free knowledge. Further, since the researcher must interact with research subjects in order to gain knowledge, the process of research itself affects the perceptions of both researcher and participant. This means that “objective” observation, in which the researcher passively accumulates knowledge about the world, is not possible. Again, it may be noted that parallel insights have been made about subject-dependence and the impossibility of purely objective observation in the natural world (Heisenberg, 1949; Monod, 2004). Interpretive research is commonly associated with nondeterministic assumptions, the process form of theory, and the use of qualitative data and analytical techniques.

Although it is common to speak of interpretivism as if it represented a single metatheoretical position, interpretivism is actually a set of several belief systems. Ontologically, interpretive researchers commonly take one of two positions: *internal realism* – in which reality is seen as an inter-subjective construction that is shared between individuals, and *subjective idealism* – in which reality is seen as a personal construction of single individuals (Nandhakumar & Jones, 1997). Interpretive perspectives can be divided into “weak” and “strong” forms. Weak interpretive positions hold that the true state of the world cannot be known. This implies that knowledge of reality is inaccessible, and therefore must always be treated as mediated by the subjective understanding of observers. Strong forms of interpretivism hold that since knowledge of reality is a social construction, “Reality” in the sense of a separate domain of existence apart from the observer, does not exist (Rorty & Williams, 1980). Strong forms of interpretivism have been strongly criticized for undermining the basic principles of rationality (Mingers, 2006).

Interpretivism has become an important perspective in IS research (Walsham, 1995a). However, this was not always the case. In the early days of IS there was no significant discussion about metatheoretical orientation and methods. Positivist assumptions, and the methods that are supported by positivist assumptions, were ubiquitous in the field (Hirschheim & Klein, 2012, p. 204). This state of affairs continued well into the mid-80s. Walsham (1995a, p. 381), making a larger point about the acceptance of interpretivism in IS, cites the following quote:

A paper in the Theory and Research category should satisfy the traditional criteria for high quality scholarly research. It should be based on a set of well-defined hypotheses, unbiased and reproducible procedures for collecting evidence that supports or refutes the

hypotheses, and sound analytical procedures for drawing appropriate conclusions from the evidence.

(Emery, 1989)

This quote, from the (then) editor of the principal journal in IS – MIS Quarterly – demonstrates the implicit assumption that research should use the forms and assumptions associated with positivist research exclusively. The transformation of the IS discipline that led to the broader adoption of interpretive methods began in 1984, when researchers began to express concern over the ability of traditional research methods in IS to meet the needs of the discipline. This led to the organizing of a colloquium by the IFIP TC8 Working Group to critically examine then-current research approaches in IS and discuss the need for new approaches (Hirschheim & Klein, 2012, p. 207). This colloquium provided a forum for the expression of concerns about issues such as the exclusive use of research methods that were drawn from the natural sciences. The colloquium itself was recognized as a milestone in the acceptance of new approaches to research in the field.

However, it was not the end of the story. It will, for example, be recognized that the editorial cited above, (Emery, 1989) which stated the expectations of the editor of the most prestigious journal in the field, was produced in 1989, five years after the colloquium. Changing the fundamental metatheoretical assumptions of a field is always a process, never an event, and the duration of the process can often be years. The colloquium was obviously a step toward the opening of IS to a number of different perspectives, but it did not mean that the overall approach of the field was suddenly changed. That took time, there was a significant amount of debate and dispute within the field, and there is considerable evidence that the debates were quite contentious at times (R. Weber, 2004). Another milestone appears to have occurred in 1991, when three respected scholars within the discipline produced two influential papers: (A. S. Lee, 1991), and (Orlikowski & Baroudi, 1991), calling for the integration of interpretive research into the field's body of research.

### **2.2.1.3 Pluralism**

Eventually, a fundamental transformation in the definition of “high-quality research” in the discipline did occur. An incoming editor of MISQ in 1993, wrote a Theory and Methods editorial that explicitly stated that the journal welcomed high-quality research from both positivist and interpretive perspectives (DeSanctis, 1993). Papers establishing methodological standards for interpretive research started to be published by the field's top journals (H. K. Klein & Myers, 1999; Walsham, 1995a, 1995b). Interpretivist research became an accepted mode of enquiry within IS. It is to be noted that this does not mean that the positivist metatheoretical position was eliminated from the field (on the contrary, most reviews of scholarly output in the field indicate that it continues to be the most commonly-used approach (W. Chen & Hirschheim, 2004; Nandhakumar & Jones, 1997)). It also does not mean that the field became

positivist-interpretivist. On the contrary, I contend that the transformation that the field underwent at this time is that from having a *single* metatheoretical model to *multiple* metatheoretical models. By the 2000s, there were three common models being applied in IS research: positivism, interpretivism and critical research (H. K. Klein, 2004). New approaches are now commonly proposed in papers in the discipline's key journals and conferences (Mingers, 2004b) and discussion of metatheories (which are commonly referred to in the IS literature as “paradigms”) is now a common topic of scholarly debate within the field. This represents a revolutionary change within the discipline from the earlier position, in which positivism was the only commonly accepted model for research.

The IS field originally adopted positivist assumptions and methods from its reference disciplines in the late 1950s to early 1960s. At that time empiricist assumptions closely associated with the behaviorist movement in psychology (which will be discussed below) were a dominant perspective in the behavioral sciences, and positivist/empiricist assumptions became the default position in IS. Approximately 30 years later, possibly triggered by the strong challenges to positivist assumptions that were sweeping through the reference disciplines, a reevaluation of metatheoretical approaches in IS took place. A breakdown in the confidence that many IS practitioners had in the positivist position eventually led to the adoption of a new approach: one that made space for multiple metatheoretical models within IS. One of the first of these alternate approaches was interpretivism, but it was not to be the last. Critical (H. K. Klein, 2004), critical realist (Mingers, 2004c), integrative (A. S. Lee, 1991; Newman & Robey, 1992), and other positions are being adopted within the field.

It might be expected that the adoption of a pluralistic approach to methodology would be accompanied by a rethinking of, and perhaps a revolution in, the representational strategies for system utilization in IS research. In the next section, I will review the literature on system utilization in the field, and attempt to explain what actually happened, and propose a possible explanation.

### **2.2.2 System Utilization in IS Research**

The IS discipline emerged approximately five decades ago from computer science, organizational studies, management studies and the behavioral sciences; and has developed, over time, its own distinct subject matter and schools of thought (Gregor, 2006). While it was once noted for its reliance on its source disciplines for both theories and exemplars of research methods (Keen, 1980), scholars have more recently declared that IS has matured, developing its own research perspectives, and is now in a position to act as a reference discipline itself (Baskerville & Myers, 2002). Some support for this position can be seen in the divergence of IS research from that in a closely-related sister discipline that is also focused on the use of information technology by humans — the discipline of Human-Computer Interaction (HCI). The principal methodologies for research in HCI and in IS, have been steadily diverging (Carroll, 2003; W. Chen & Hirschheim, 2004). IS is, to a large extent, going its own way in terms of research norms. One of those norms, as noted earlier, embraces some heterogeneity of metatheoretical positions; but there are

some positions, and methodologies, which are dominant, heterogeneity notwithstanding. I will now look at these norms with regard to one central issue, the conceptualization and measurement of system utilization.

There are a number of major categories into which IS research has been divided. While most have relied on ontological approach and research methods for classification (Hovorka et al., 2008), IS research can be categorized using metatheoretical assumptions, research methods, level of abstraction, type of theory, etc. In this section, I will look at utilization research using two categories which were used by Mingers (2003b): nomothetic and ideographic. Nomothetic research looks at large samples, is typically quantitative, typically uses positivist assumptions, and is usually concerned with finding patterns within a sample that can be generalized to a wider population, consistent with the positivist goal of finding general causal laws (in behavioral research, such laws typically are probabilistic). Idiographic research looks at a (relatively) small number of participants - often within a single or limited research context, it is typically qualitative, typically uses interpretive or critical metatheoretical assumptions, and is usually concerned with getting a deep understanding of a particular event or phenomenon within a specific context. It is to be noted that the above generalizations obviously have significant exceptions, but they do represent the general trends concerning the respective research categories.

Most quantitative research in IS is positivist in orientation (Straub, Gefen, & Boudreau, 2004), despite the fact that, in theory, quantitative methods may also be used by interpretive researchers, who may then use interpretive assumptions to understand the results (Nandhakumar & Jones, 1997). However ideographic research is frequently applied using either – or both – positivist and/or interpretive assumptions (Walsham, 1995a). The distinction between the two types of studies is not always clear, even when authors explicitly align themselves with one position (Walsham, 1995a, p. 384). One widely-cited model for classifying studies as interpretive or positivist is the criteria used by Orlikowski and Baroudi (1991), which has, in turn, been widely adapted and adopted by subsequent authors, including Walsham (1995a) and W. Chen and Hirschheim (2004). Their approach will be relied on for the analysis below.

A note about how critical studies will be treated in this project. Critical studies are commonly considered the third of the major ontological positions within IS research, along with positivist and interpretive studies (H. K. Klein, 2004). However, in most, if not all, of the major reviews that have looked at the mainstream publication outlets, actual published examples of critical studies have been rare, or nonexistent, e.g., (W. Chen & Hirschheim, 2004; Nandhakumar & Jones, 1997; Orlikowski & Baroudi, 1991). Furthermore, the ambiguity problem that sometimes occurs when trying to classify studies that claim to be interpretive but seem to apply positivist assumptions, is even more acute when trying to separate interpretive from critical studies. For example, (Walsham, 1995a) – an explicitly interpretive account of the emergence of interpretive research in IS – is quite explicit about its goal of transforming the restrictive social conditions which alienate interpretive researchers from the mainstream (Walsham,

1995a, p. 392). The interpretive focus on taking the participants' perspective makes it likely that this inherent advocacy will be a feature of many interpretive studies.

The implication of this is that the number of unambiguously critical studies that are part of the mainstream discourse in IS is likely small. Indeed, for reasons that I will proffer later in this section, there has been less adoption of non-positivist research designs in general in IS than one would expect, given the vibrant discussions which have taken place in the discipline on alternate and integrative approaches. The intention in this part of the review is to identify and analyze the dominant metatheoretical approaches that have operated in IS over the past several years, and look at the effect of those dominant approaches on the way that system utilization is generally approached in the discipline. While critical studies are certainly a valid and accepted approach within IS, the evidence does not suggest that the critical approach constitutes a dominant approach. As such, in this section, I will focus on the interpretive and positivist approaches.

It should be noted that the way some pieces of research — or even research programs — are classified, is, to some extent, an arbitrary decision that may vary from analyst to analyst. For example, work applying Adaptive Structuration Theory (AST) (DeSanctis & Poole, 1994) is noted in Pozzebon and Pinsonneault (2001, p. 207) to largely apply positivist assumptions. However, Orlikowski and Scott (2008) place AST within their Research Stream II, which has less typically “positivist”-style assumptions than Research Stream I (see (Orlikowski & Scott, 2008, p. 438)). Since my intention in this section is to discuss the dominant paradigms that explain certain overarching trends in the IS literature, I will acknowledge that there may be some level of subjectivity to the way that I classify and interpret some of the work that is cited. However, I believe the evidence for the underlying trends I cite does, in aggregate, exist.

### ***2.2.2.1 Nomothetic Approaches***

The management sciences in general, and IS in particular, have long been dominated by empiricist assumptions, and positivist methods that are based on those assumptions (W. Chen & Hirschheim, 2004; Mingers, 2005, p. 202; Nandhakumar & Jones, 1997; Orlikowski & Baroudi, 1991). These assumptions and methods have had a significant role in shaping previous IS research, and are still a powerful force in the discipline today (Hirschheim & Klein, 2012). Cross-sectional studies using nomothetic designs, survey methods, and quantitative analysis are the most common type of research done in IS (Ahmad, Lyytinen, & Newman, 2011; Cheon, Groven, & Sabherwal, 1993; Orlikowski & Baroudi, 1991). In this research tradition, IS phenomena are investigated by the construction and testing of theoretical models which describe the causal relationships between independent and dependent variables. These hypothesized relationships are tested using statistical measures of association, and large, systematically-selected samples are necessary to ensure confidence in the findings (Sabherwal & Robey, 1995, p. 304).

In this research stream, system use has been acknowledged as one of the most important research areas. Despite this fact, there has been surprisingly scant theoretical research on the concept of system use itself for much of the history of the IS discipline (Burton-Jones & Straub, 2006). While there have been several calls for such research in the past (DeLone & McLean, 1992; Straub et al., 1995), there has only recently been a surge of interest in system use as a research topic (Barki et al., 2007; Elie-Dit-Cosaque & Straub, 2010; Fidock & Carroll, 2009; Gerpott, 2011; Grgecic & Rosenkranz, 2011; Guinea & Markus, 2009; Kjærgaard & Jensen, 2008; McLean et al., 2011; H. Sun & Fricke, 2009; Tate & Evermann, 2009). It should be noted that not all of the studies in the preceding list represent classical nomothetic studies. Some, such as (Guinea & Markus, 2009) are conceptual, and some, such as (Kjærgaard & Jensen, 2008), use an intensive approach. However all of them have in common the goal of getting a deeper understanding of how systems are used, and finding ways to operationalize that understanding by creating better measures of utilization. The search for “better” measures of use is, in a way, an implicit critique of the way that utilization has been conceptualized and measured in many prior studies. That has been heavily influenced by the success of one of the most influential streams of research in the discipline.

One of the most extensively-researched topics in IS research over the past two decades is technology adoption. How to predict whether users will use technological systems has become a central question in IS and has shaped a number of related streams of research. It is widely accepted that one of the main drivers of technology adoption research has been the Technology Acceptance Model (TAM), which was introduced by (F. D. Davis, 1989; F. D. Davis, Bagozzi, & Warshaw, 1989). The TAM has the distinction of being one of the few theories that was developed in IS (Tams, 2010), which has been widely applied in other disciplines (see (Bagozzi, 1990; Bagozzi, Davis, & Warshaw, 1992; Dabholkar & Bagozzi, 2002)). First proposed in Davis’ doctoral dissertation (F. D. Davis, 1986), in its most basic version TAM provided a simplified operationalization of the Theory of Reasoned Action (Fishbein & Ajzen, 1975), based on Rogers (2003)’s diffusion of innovations model, for measuring a user’s intention to use an IT system (Fishbein & Ajzen, 1975). It was comprised of two variables: Perceived Usefulness (distinct from another construct of the same name coined in 1986 by Franz and Robey (1986)), and Perceived Ease of Use; proxies for Rogers (2003)’s Relative Advantage, and Complexity factors, respectively (Karahanna, Straub, & Chervany, 1999). TAM provided, essentially, a parsimonious variance model for measuring user perceptions and intentions in order to make a single prediction: would the user accept (use) or reject (not use) the system? The emphasis on prediction is an indicator of the positivist/empiricist assumptions that were a foundation for the model. It was originally developed with two aims: to further the understanding of the determinants of the use/not use decision, and to form a theoretically rigorous basis for acceptance testing of systems (F. D. Davis, 1986). However, the papers that introduced it to the field: (F. D. Davis, 1989; F. D. Davis et al., 1989), became two of the most highly-cited papers in IS (over 28,000 combined citations up to January 2014, according to Google Scholar), and inspired an extensive stream of research. The body of literature inspired by TAM and the resulting surge of interest in the topic of adoption has dominated the IS field. Wade (2011) reported the findings from a survey of 1,000 IS lifecycle articles in 7

leading IS journals over the past 20 years, and the categories of “Acceptance” (13%) and “Adoption” (67%) accounted for a total of 80% of the articles.

TAM was used widely by researchers both within IS and in fields outside the discipline such as marketing (Bagozzi, 1990; Dabholkar & Bagozzi, 2002). There is a large literature on TAM, reflected both in the number of citations of its initial studies, and in the several reviews and critiques it has generated (Legris, Ingham, & Colletette, 2003). TAM has spawned a huge number of studies, and there are many different ways of analyzing the literature that has been spawned from it. Some of the streams of research produced by researchers using, critiquing or extending TAM include:

1. Reviews and replications of, and commentaries on, TAM research, e.g., (Adams, Nelson, & Todd, 1992; Benbasat & Barki, 2007; Hendrickson & Collins, 1996; Hu, Chau, Sheng, & Tam, 1999; Lederer, Maupin, Sena, & Zhuang, 2000; Y. Lee, Kozar, & Larsen, 2003; Legris et al., 2003; Morris & Dillon, 1997; Straub & Burton-Jones, 2007; Szajna, 1994)
2. Extensions to, and integrations of other models and constructs into, TAM, e.g., (Ritu Agarwal & Prasad, 1999; Bajaj & Nidumolu, 1998; Chau, 1996; Angelika Dimoka & Davis, 2008; Dishaw & Strong, 1999; Hubona & Cheney, 1994; Igarria, Guimaraes, & Davis, 1995; Igarria, Zinatelli, Cragg, & Cavaye, 1997; Jackson, Chow, & Leitch, 1997; Karahanna et al., 1999; R. Thompson, 1998; Venkatesh, 2000; Venkatesh & Bala, 2008; Venkatesh & Davis, 1996; Venkatesh & Davis, 2000)
3. Alternative models for exploring technology acceptance and use beside TAM, e.g., (Moore & Benbasat, 1991, 1996; Sykes, Venkatesh, & Gosain, 2009; H. H. Teo, Wei, & Benbasat, 2003; R. L. Thompson, Higgins, & Howell, 1991; Venkatesh, Morris, Davis, & Davis, 2003; E. V. Wilson, Mao, & Lankton, 2010)
4. Comparisons of TAM with alternate models, e.g., (Bagozzi et al., 1992; Burton-Jones & Hubona, 2006; F. D. Davis et al., 1989; Haynes & Thies, 1991; Matheison, 1991; S. Taylor & Todd, 1995b)
5. Effects of hedonic factors on acceptance and use, e.g., (T. S. Teo, Lim, & Lai, 1999; Van der Heijden, 2004)
6. Research on the impact of gender and culture on the effects of TAM variables, e.g., (Gefen & Straub, 1997; Straub, 1994; Venkatesh & Morris, 2000)
7. Comparison of perceived usefulness vs. perceived ease of use, (Keil, Beranek, & Konsynski, 1995)
8. Comparisons of intention to use (commonly measured as a proxy for actual use in acceptance studies) with actual use e.g., (Pentland, 1989; Straub et al., 1995; Szajna, 1996)
9. Commentaries and prescriptive articles on method variance in quantitative IS research (Burton-Jones, 2009; Tate & Evermann, 2009; Tate & Evermann, 2012)

It seems fair to say that a great deal of research in IS, particularly nomothetic research applying positivist assumptions, has been aimed at TAM. The observation that TAM has a dominant role in IS is not new —

the same observation has been made in recent critiques of TAM and its effects such as (Benbasat & Barki, 2007). However, what is significant – and less commonly recognized – is the role that the timing of the emergence of TAM, and its influence in IS, has played in the way that system utilization is conceptualized in the field. When TAM was introduced, in 1989, IS was undergoing a paradigm shift, from positivist to multi-metatheoretic. In concert with that change, one could have expected that there would simultaneously be a transformation in the way that system use is defined as a construct. The “quantification” measures that were appropriate for the “clerical automation” contexts that defined the early days of the field (Hirschheim & Klein, 2012), would seem to be obviously unsuited to the richer and changing contexts that were emerging as IS became more and more a core business tool for communication and decision support. That this did not happen, and that system use has been conceptualized and measured in largely the same way it had always been until very recently (Burton-Jones, 2005; Burton-Jones & Straub, 2006), seems to be a little-remarked but real consequence of the rise TAM as a dominant model.

The effect of TAM has been felt beyond the specific streams of research that have directly used the TAM model to investigate particular phenomena. Several streams of IS research which are not directly concerned with IT acceptance or adoption have adopted cross-sectional study designs and quantitative instruments for investigation that have similarities to F. D. Davis (1989)’s approach, despite the fact that such instruments are not an obvious fit for the topics of those research streams. Examples include the Service Quality stream, which has been dominated by the use of a survey-type instrument – Parasuraman, Zeithaml, and Berry (1988)’s SERVQUAL scales – despite well-known concerns about the reliability of the instrument, and conceptual problems with applying it in many IS service domains (Tate & Evermann, 2010).

Nowhere is this attachment to TAM-style research methods more vivid than in the recent literature on post-adoptive IS use. In response to recent critiques of the preponderance of technology acceptance and adoption research (see (Bagozzi, 2007; Benbasat & Barki, 2007; Straub & Burton-Jones, 2007), many researchers have adopted a new focus – understanding the phenomena that emerge after the adoption of IT: post-adoption (Jasperson, Carter, & Zmud, 2005). The goal of this research stream is to enhance understanding of how users decide to maintain, increase, enhance, decrease or discontinue their use of systems and system features after the adoption decision is made. Both conceptual and empirical work has been done on developing better understandings of how use patterns develop over time. This work is fundamentally quite different from the work on adoption. Whereas adoption studies have at their center an *event*: the user decides to use / not use the system; work on post-adoption or continuing use almost invariably describes a *process*: how the user’s utilization of the system evolves over time. Despite this, much of the empirical research in this area has taken the form of cross-sectional quantitative studies utilizing variance theory, sometimes using intention as a proxy for actual use (Thatcher, McKnight, Baker, Arsal, & Roberts, 2009). While in some ways this could be seen as a response to Benbasat and Barki

(2007)'s comments on the restrictive nature of TAM research (Benbasat & Barki, 2007, p. 213), in other ways it seems reflective of the very limited conceptual tool set that is often brought to bear on diverse research problems in IS. This is especially so in light of the fact that the “rational-choice” models of human decision-making that form the foundations of TAM (Fishbein & Ajzen, 1975), have been extensively critiqued and are now widely rejected within the reference discipline in which it was developed (Kahneman, 2011; Kahneman & Tversky, 1979; Tversky & Kahneman, 1974). This problem of insufficient attention to developments in the reference disciplines with regard to theories in IS which are developed from them has been noted by several researchers (Guinea & Markus, 2009; Tate & Evermann, 2012).

The influence of TAM and TAM-inspired research may be a factor in the dominance of quantitative positivist methods – particularly the survey method – in IS, but it was not the initiator of such research in the field. Straub, Ang, and Evaristo (1994) cite Hamilton and Ives (1982), Ives and Olson (1984), and Farhoomand (1987) – all of whom published before TAM was introduced to the discipline in 1989 – as expressing concern about the indiscriminate application of the survey method to various research areas without consideration of its suitability. The perspective that that state of the field reflects, it must be noted, is consistent with the positivist assumptions that were then the dominant metatheoretical position in the field. My contention is that the success of the TAM model, and the wide application of TAM in a number of domains after its introduction, had the effect of suppressing deep reconsideration of the way that system utilization was commonly represented in IS.

The IS field was in a transitional period in the late 1980s, with an opening up of the metatheoretical assumptions of the discipline to other perspectives. Under normal circumstances, this might have tended to lead the field to open up as well to a wider range of methods for conceptualizing what system utilization actually is, and how it ought to be measured. I contend that the success of TAM – and the accompanying opportunities for researchers to pursue rewarding puzzle-solving work within the “paradigm” of TAM – suppressed this tendency. While IS as a field might have philosophically acknowledged the limitations of a positivist-only orientation for research; in practice, it continued to use a reductive and restrictive view of use – “system use defined as an amount or frequency” (Benbasat & Barki, 2007, p. 213) – to guide research. New IS researchers tended to be taught to use survey methods and do TAM – or TAM-style – studies. The effects of this on publication patterns in the discipline may also have been exacerbated by the career dynamics of IS junior researchers (see Applegate & King, 1999; W. Chen & Hirschheim, 2004, p. 224), making it more difficult for researchers to apply “non-standard” methods. This is the essence of Benbasat and Barki (2007)'s criticism of the effect that TAM has had on IS research.

However, while nomothetic research, primarily using survey methods, has been the dominant type of research in IS through much of its history, it has not been the only type. There has also been a tradition of idiographic research. I will look at this in the following section.

### **2.2.2.2 Idiographic Approaches**

The largely positivist-only perspective within IS (Emery, 1989) that prevailed in the late 1980s – early 1990s did not preclude the use of idiographic methods. Even before the rise of interpretive and other alternate metatheoretical models, papers were published on idiographic methods utilizing positivist assumptions (A. S. Lee, 1989b). However, idiographic methods came into their own with the widespread adoption in the field of interpretivist assumptions. With interpretivism's focus on analyzing the subjective understandings and individual perspectives of research participants, idiographic qualitative methods can seem a natural fit for that metatheoretical approach, and articles about case study methodology (Walsham, 1995b), ethnographic methods (Myers, 1999), and, ultimately, a two-volume special issue on intensive methods in the field's premier journal (Markus & Lee, 1999, 2000), established idiographic methods as an ascendant approach to research in the discipline. It is important to emphasize, however, that idiographic research does not necessarily employ constructivist assumptions. For example, idiographic methods are often used with process theories (Mohr, 1982; Pentland, 1999), and process theories often have goals of prediction based on analysis of patterns of events, goals which may be seen as inherently empiricist (Ahmad et al., 2011). Indeed, Sabherwal and Robey (1995) note that variance and process strategies share the epistemological assumptions that the social world is objective and observable – realist assumptions. Even declarations by the authors that their papers use interpretive assumptions can be somewhat ambiguous, or even misleading. Walsham (1995a), for example, shows that the meaning of “interpretive” research can be interpreted by different researchers in different ways, making it difficult to classify some studies (Walsham, 1995a, pp. 384, 385).

Within the category of ideographic research, therefore, there are at least two major schools of metatheoretic thought: interpretive/constructivist, and positivist/empiricist. They can typically be identified by the design of the study, the nature of the research questions and the type of assumptions applied by the researchers. Identifying the metatheoretical assumptions of the researchers by the research method is often impractical because some methods can be applied using different metatheoretical positions. For example, there are guidelines in IS for conducting both positivist (Dubé & Paré, 2003) and interpretive (Walsham, 1995b) case studies. Other methods, such as grounded theory (Glaser & Strauss, 1968; Strauss & Corbin, 1998), are said to be “paradigmatically neutral” (Butler & O'Reilly, 2010; Urquhart, Lehmann, & Myers, 2010), meaning they can be applied using any metatheoretical approach. This can lead to some confusion about the link between methods and metatheory. For example, Urquhart et al. (2010) notes that grounded theory has been called positivist, interpretivist, and critical. In intensive idiographic studies, both interpretive and positivist studies have in common the goal of intensively understanding a phenomenon within a given context. However, the assumptions that go along with the metatheoretic positions that are held by researchers in each tradition lead to there being different critical issues surrounding each type of study. I will look at each in turn, beginning with positivist intensive studies.

One of the most hotly-debated topics surrounding positivist idiographic studies is generalizability. When conducting research consisting of statistical analysis of relationships within a sample (Hovorka et al., 2008), drawn from a defined population, well-defined algorithmic procedures govern how those analyses should be conducted. When the analyses are complete, well-defined rules govern how findings from those analyses can be generalized to the populations from which they were drawn. Such well-defined rules do not exist for qualitative data. The result has been a vibrant debate within the field, first about how to conduct “scientific” analysis of qualitative data (A. S. Lee, 1989a, 1989b; A. S. Lee & Hubona, 2009), and then about how findings from such analyses can be generalized, and to which populations (A. S. Lee & Baskerville, 2003; Tsang, 2013a, 2013b; Tsang & Williams, 2012). It can be observed that much of this debate has focused on case studies, the most commonly-applied qualitative positivist research method (W. Chen & Hirschheim, 2004). It is safe to say that quantitative positivist researchers – who can simply report that they have followed well-defined and commonly accepted procedures in order to validate their analyses – have an advantage over qualitative researchers, who must prove they have met less well-defined standards for analytic rigor. The professional consequences of the more time-consuming procedures and greater difficulty in validating work for publication, may be one reason why qualitative work has lagged in adoption by researchers, despite numerous calls for methodological pluralism within the field (W. Chen & Hirschheim, 2004).

Interpretive assumptions are often considered somewhat synonymous with idiographic research, given interpretivism’s concern with understanding the individual’s interpretation of the world. Nandhakumar and Jones (1997) point out that this is misleading: interpretivist researchers can use the quantitative tools of nomothetic research just as positivists can use ideographic tools. However, the output of those tools will be interpreted using interpretive assumptions. In fact, Nandhakumar and Jones (1997, p. 117) found from a review of studies published in three of IS’s top journals that interpretive researchers use methods which involve “low engagement” with participants more often than one would expect, given the assumptions of interpretivism. Nonetheless, interpretive research in IS has been more often associated with qualitative intensive designs than the quantitative and nomothetic designs that are also available to interpretive researchers. Interpretive researchers seek to access the subjective meanings assigned to phenomena from the perspective of participants. The concept of “generalizing” to a population that is a foundation of positivist contributions to knowledge does not apply in interpretive studies. The ultimate goal of an interpretive analysis depends on the “stream” of interpretivism that a researcher follows. Interpretivism is not one perspective, and can be seen as having “weak” and “strong” forms. Weak interpretive approaches use internal realist assumptions and aim to access the intersubjective construction of reality shared by participants. Strong interpretive approaches see all representations of reality as personal constructions that cannot be shared (Nandhakumar & Jones, 1997, p. 110). Several scholars have pointed out the fact that subjective idealist assumptions pose basic problems for the practice of scientific research (Mingers, 2006; R. Weber, 2003).

### **2.2.2.3 Norms and Anomalies**

The nomothetic and idiographic approaches outlined above each are associated with certain norms concerning how system utilization is conceptualized and measured. These norms have direct effects on the way that system utilization has been studied in each research stream. The effects of these norms have also led to anomalies within each stream that have been the subject of concern by prior researchers.

Calls for a serious reconsideration of the norms for conceptualizing and measuring use in the nomothetic tradition have been being made for some time (Straub et al., 1994). Those calls have been bolstered by findings which indicate that commonly-accepted proxies used in measuring use are, in fact, problematic. For example, the use of self-report and intentional measures has continued to be a primary method of measuring dependent variables in studies of acceptance, use, and even continuing use, despite a growing body of research suggesting significant validity problems with such measures (Gerpott, 2011; Straub et al., 1995; Szajna, 1993, 1996).

Some of the problems which have been pointed out go even further, questioning the commonly-accepted norms for applying statistical methods in IS. The nomothetic research tradition in IS is highly dependent on statistical modeling as a research method. Mingers (2003a) has critiqued the way that statistical modeling is generally performed in IS research, integrating a number of criticisms that have been pointed out by prior authors (Mingers, 2003a, p. 5). Among the anomalies he points out are:

- A reductionist view of causation that only looks at associations between variables (i.e., a Humean view), ignoring causal mechanisms
- An unsubstantiated assumption of event regularities (inherent in the Humean view)
- Explanations that lack ontological depth, since quantitative models must generally include variables that occur at the same level of aggregation
- Unsupportable assumptions about both extrinsic and intrinsic closure in causal models
- Unsupportable assumptions about stability in the relationships found in the data
- The dependence of real-world modeling on ad-hoc judgments and tacit knowledge on the part of researchers. This undermines the positivist assumption of “objectivity” in making inferences
- The atheoretic nature of real-world modeling
- The reliance of significance testing on unrealistic assumptions
- The fact that many models simply do not demonstrate useful levels of predictive validity

The last point is particularly significant. The major goal of research conducted using positivist assumptions is the generation of reliable, accurate predictions about future states of the world. Yet few models demonstrate the ability to generate useful predictions, both within IS and beyond (Sherden, 1998). Further, those which do, often demonstrate an ability to make predictions which are relatively obvious. For example, E. V. Wilson et al. (2010) state “Researchers have been highly successful in

predicting and explaining IT use in conditions where there is frequent need for the technology.” This brings to mind the comment of Weick (1989) that theorists often construct theories that are trivial because they are focused on the tractability (as per Mingers, 2003a, p. 7), rather than the usefulness of their theories. Indeed, it has been noted that the most successful theory produced by this tradition of research – F. D. Davis (1989)’s TAM model – tells us little about why the measured relationships exist and thus contributes less to knowledge than might be supposed. Straub and Burton-Jones (2007) go even further, pointing out that common method variance cannot be ruled out as an explanation for the measured effects of TAM. These anomalies have long been recognized, but, for the most part, nomothetic quantitative positivist research in IS has continued without seriously addressing them.

Idiographic research includes examples of both positivist and interpretivist approaches. In positivist idiographic research, there has been a vibrant discussion surrounding the issue of generalizability (A. S. Lee & Baskerville, 2003; A. S. Lee & Baskerville, 2012; Tsang & Williams, 2012). Underlying this discussion is the fact that the rules for generalizing from idiographic qualitative research are much less developed, and not nearly as universally accepted, as the rules for generalizing findings from samples to populations in quantitative research. In addition, in positivist research, qualitative research is often treated as only appropriate for research in areas that lack well-developed theoretical models (Daft & Why, 1985). Integrative frameworks for combining both qualitative and quantitative methods are rare (see Gable, 1994 for one example). In this tradition, case studies have often been approached as a means to isolate the contextual factors that influence outcomes (Gregor, 2006, p. 622). They have also been promoted as a method for generating theoretical explanations in IS through mechanism-based strategies (Avgerou, 2013). However, generalizing from such studies is hindered by the lack of universal construct definitions (Benbasat & Zmud, 1999).

The second area in which ideographic approaches are commonly used is in interpretive ideographic studies. Interpretive and constructivist approaches grew, in large part, out of critiques of positivism (Mingers, 2006, p. 17). They address many of the fundamental critiques of positivist assumptions; however, they have been criticized for doing so by disregarding, or in the case of “strong interpretivist” approaches, abandoning, the notion of the external world (Mingers, 2006, p. 19). The existence of the external world is regarded by philosophers as impossible to prove, but it has been noted that most people, including interpretivists, tend to act as if they believe it exists (R. Weber, 2004). Further, from a realist perspective, it is difficult to see how epistemic relativity can be defended without undermining basic principles of science (Mingers, 2006, pp. 17-19).

It should be noted that in both streams of ideographic research – positivist and interpretive – there is a lack of a universal model for conceptualizing and describing system utilization. In positivist ideographic research there has been a lively debate between researchers who believe that the lack of universal construct definitions hinders IS from developing a cumulative tradition of knowledge (Benbasat & Zmud,

1999), and those who believe that universal definitions and cumulative traditions are inappropriate for IS (Davenport & Markus, 1999).

#### **2.2.2.4 Emerging Perspectives**

While there have been acknowledgements and challenges to the anomalies in the representation and measurement of system utilization in IS over the past several years, there has recently been a surge of interest in this issue in the research literature, and novel proposals have been made for new methods to represent the interaction of users and systems. Indications of a new interest in this area may be seen in the work on system use in (Burton-Jones, 2005), and the subsequent (Burton-Jones & Gallivan, 2007; Burton-Jones & Grange, 2012; Burton-Jones & Straub, 2006). Critiques of the current models of measurement of use – along with some proposals for corrections – have come from (McLean et al., 2011; Tate & Evermann, 2012). Extensions of the current conceptualizations of use have come from (Barki et al., 2007), (Elie-Dit-Cosaque & Straub, 2010).

In addition, there have been a number of new metaphors being proposed for ways to represent the interaction between users and systems in research. These include the Sociomaterial perspective (Orlikowski, 2007, 2009; Orlikowski & Scott, 2008); Secondary design (Germonprez et al., 2011); Imbrication (Leonardi, 2011); and “third wave” IS research (Seidel & Berente, 2013). Some of these perspectives are not entirely new (e.g., Germonprez et al. (2011) echoes ideas that go back to McLean (1979)), but taken as a whole they suggest that IS as a field is evolving in the way that it represents perhaps the central phenomenon that it investigates: the way that people use IT systems.

### **2.2.3 Discussion**

It should be mentioned at the outset that the above perspectives on system utilization do not exhaust the scope of research that has been done in IS over the past 40+ years. Some of this work has looked specifically at phenomena which are conceptually related to the utilization of IT artifacts in novel and useful ways. The notion that end users may also function as “developers” if given access to the tools and techniques needed to modify the systems they use was discussed in the 1970s by McLean (1979). Other work – some of it rooted in Rogers (1995)’s theory of the diffusion of innovations – has discussed the adaptation and reinvention of IT by adopters, rather than designers (Griffith, 1999; Orlikowski, Yates, Okamura, & Fujimoto, 1995; Schmitz, Webb, & Teng, 2010). Some have proposed that this adaptation tends to be driven by misalignments between user tasks and technology features (Lassila & Brancheau, 1999; Leonard-Barton, 1988; Majchrzak, Rice, Malhotra, King, & Ba, 2000; Tyre & Orlikowski, 1994) and have proposed ways of measuring and understanding the dimensions of such misalignments (Goodhue, 1995a, 1995b; Goodhue & Thompson, 1995). There has been work on stage theories of IS implementation, which propose that novel use patterns emerge from higher-order ‘experimental’ use behaviors which emerge late in the implementation cycle (Jasperson et al., 2005; Kwon & Zmud, 1987; Saga & Zmud,

1993; Zmud & Apple, 1992), and critiques of stage theories (Benbasat, Dexter, Drury, & Goldstein, 1984; Mohr, 1987; Sabherwal & Robey, 1995). There have been extensions to the literature on adoption that have looked at emergent use patterns as a feature of certain adoption types (Klonglan & Coward Jr, 1970; Nah, Tan, & Teh, 2004; Wang & Hsieh, 2006), and conceptual definitions for looking at the factors – at both the individual and collective levels that drive innovative user behaviors (R. Agarwal & Prasad, 1998; Ahuja & Thatcher, 2005; Gallivan, 2001; Nambisan et al., 1999; Swanson & Ramiller, 2004). There have also been acknowledgements of the limitations of the dominant models for exploring utilization in IS, and proposals for new models, such as those proposed by (Jain & Kanungo, 2005; Singletary, Akbulut, & Houston, 2002; Heshan Sun, 2012).

This considerable existing literature demonstrates that the basic issue of needing to develop a deeper understanding of how systems are used and how users' interactions with systems result in novel appropriations of technology is recognized in IS as an important research domain. However, little of this research has drawn on the wider extant literature on creativity, which is odd, given that the common thread which ties all the disparate streams of research referenced above together is that they concern end users – whether continuing users or adopters – developing or discovering new ways to use technology that are self-directed, unanticipated, novel, useful, and appropriate for a purpose. Even if the emergent utilization processes are not formally measured and certified as 'creative', the relevance of a literature which looks at ideation processes, and how novel ideas are generated, implemented, and understood, to many of the above research domains would seem apparent. Its relative absence from the body of work on this type of behavior in IS seems odd.

One clue about why this may be can be gleaned from a closer look at the methodological approaches used in many of the above studies. Many (e.g., (R. Agarwal & Prasad, 1998; Ahuja & Thatcher, 2005; Goodhue, 1995a; Goodhue & Thompson, 1995; Jain & Kanungo, 2005; Nah et al., 2004; Nambisan et al., 1999; Singletary et al., 2002; Heshan Sun, 2012; Thatcher et al., 2009; Wang & Hsieh, 2006)) are wholly or partially survey-based studies that seem aimed at finding a “dependent variable” (DeLone & McLean, 1992), a model that can that can “explain” innovative user behaviors, in much the way that TAM “explains” user adoption behaviors. However there is little in the current findings from this body of research to confirm that such an approach is ideal to understanding how users apply their creative abilities to the appropriation of systems. Put another way, it is unclear that such a variable exists, and if it does, it is unclear that we understand user appropriation well enough to define it.

The IS discipline has a number of varied and multifaceted research communities (Burton-Jones & Grange, 2012; A. Dimoka, Pavlou, & Davis, 2010; Tan & Hunter, 2002). However, even those, including this researcher, who feel that one strength of the IS discipline is its openness to a variety of perspectives, would concede that there are some types of research which clearly dominate scholarly output in the field, and in its top journals. It has consistently been found that there is a single set of dominant philosophical

assumptions in the discipline (Iivari, Hirschheim, & Klein, 1998, p. 165). The empirical evidence from a number of reviews and studies of both research content and publication patterns in the discipline is clear: certain methods constitute the bulk of the output in IS, while other promising perspectives, such as narrative positivism (Abbott, 1992; Pentland, 1999), constitute a much smaller share of the published work in the most influential outlets commonly available to IS researchers. It has been a long-stated priority for journals in IS to publish a variety of types of research (DeSanctis, 1993; Webster & Watson, 2002), and yet actual attempts to do so have yielded surprisingly modest results, when tested empirically (W. Chen & Hirschheim, 2004).

One possible reason that has been proposed for this tendency in IS is the real challenges involved in introducing a new metatheoretical perspective into a scientific discipline. To focus on the specific example of the IS discipline and the shift from positivism to interpretivism, the shift in attitude among senior researchers that resulted in the intention to accept interpretivist perspectives appears to have occurred somewhere between the colloquium by the IFIP TC8 Working Group in 1984 (Hirschheim & Klein, 2012) and the MISQ editorial by DeSanctis in 1993 (DeSanctis, 1993). However, at that point, there would have been few researchers in the field who were familiar with interpretive research and able to assess it. IS graduate programs would have to hire academics who could teach interpretive research. Those academics would have to train IS students to use the methodological tools that are appropriate for interpretive research. Editors and reviewers at IS journals would have to learn how to assess interpretive papers without applying inappropriate standards for quality, a problem alluded to in (R. Weber, 2004). In context, it is not surprising that W. Chen and Hirschheim (2004) found that there was still a remarkably small portion of interpretive research being published in IS more than 10 years after the call in (Orlikowski & Baroudi, 1991).

The reason for the focus on high-level trends in this review is that it has attempted to make one overarching point: that research in IS has been enabled, shaped, and, to some extent, disabled, by a dominant set of assumptions. The single approach based on positivist assumptions dominated the field from its inception until the mid-1980s. From the mid-80s to the early 1990s the field underwent a shift in terms of the way that it defines and evaluates standards of acceptable research. Interpretive approaches and assumptions became an “acceptable” form of research in IS. For reasons that have to do with the structural dynamics at work in the careers of IS researchers (Applegate & King, 1999; W. Chen & Hirschheim, 2004), this did not (and still has not) resulted in a parity between positivist and interpretive research in terms of volume of output in the field’s top journals. However, the norms have certainly changed (DeSanctis, 1993).

There was, however, another development during the shift from a positivist-only to a multi-metatheory perspective within the field that also had an impact on the way that it developed. The development of a theoretical model that appeared able to fulfill the promise of the positivist approach: the Technology

Acceptance Model (TAM) (F. D. Davis, 1989). The TAM was powerful (for a predictive model in the behavioral sciences), parsimonious and useful. It appeared to validate and vindicate the classical positivist empiricist quantitative approach at just the moment when it was being challenged by new approaches and assumptions. The result was a strange stalemate: a strong quantitative positivist stream of research, largely aimed at findings new ways to apply, extend, or compete with TAM; and a growing, but more modest in output, stream of interpretive research. These interpretive studies were largely idiographic and focused on intensive, context-specific investigations.

Subsequent examination of the corpus of research generated by TAM has provoked some reconsideration of the extent of its contributions. TAM makes somewhat obvious predictions, and the degree to which its measured effects may be attributed to method variance is unclear (Benbasat & Barki, 2007; Straub & Burton-Jones, 2007). However, there seems to be a larger movement going on in the field that is coinciding with the reconsideration of TAM. A number of studies are coming out which are proposing new ways to look at the way system use is measured (Burton-Jones & Straub, 2006; McLean et al., 2011), and completely new metaphors for how the interaction between users and systems is conceptualized (Germonprez et al., 2011; Leonardi, 2011; Orlikowski, 2007; Orlikowski & Scott, 2008; Seidel & Berente, 2013). Taken together, these developments seem to point to an emerging shift taking place in the IS discipline at this time. Unlike the earlier shift, this revolution is not about the metatheoretical assumptions that underlie IS research, but rather about representational strategies for conceptualizing how users interact with IT artifacts. In some ways, this could be viewed as a continuation of the earlier transformation that began in the mid-80s, which was “interrupted” by the emergence of TAM.

This hypothesized shift has significant implications for this thesis and its topic. I will discuss some of these implications in the following section. Before doing so, I will generally introduce the topic of creativity, and review some of the ways in which the determinants of creativity have been conceptualized in prior research. I will then review what creativity research has been done in IS, and show how the corpus of such research in the discipline, in addition to being quite modest in volume, is also somewhat narrow in scope. I will then discuss how the historical developments that have been reviewed in this section may help to explain the limited amount and scope of the creativity research in IS up to this point.

## **2.3 Creativity**

There have been many attempts — both in the popular and scientific literature — to define the concept of creativity. These have approached the problem from a number of perspectives. The questions of how creativity should be defined, whether and how it can be measured, and whether and how it can be scientifically explained, has occupied psychologists, historians, philosophers of science, musicologists, aestheticians and lay persons throughout human history (Boden, 1996; Glück, Ernst, & Unger, 2002). The challenge of defining creativity is captured in a paradox proposed in (Hausman, 1984) as quoted by Finke,

Ward, and Smith (1992): “How is it ever possible to conceive of a truly creative idea? If you could anticipate the idea, it would be determined and not creative. If you could not anticipate it, how could you generate the idea?”

The operating definition that one chooses to use for creativity is in many ways determined by some fundamental assumptions one makes about the concept. Assumptions about the underlying nature of creativity determine, in turn, how it is defined, recognized, measured and explained empirically. Any attempt to define creativity, then, involves a process of selection. In order to fully appreciate how such selections may be made, it is useful to look at the background of creativity research.

### **2.3.1 Background**

The systematic investigation of human creativity has been a subject of study for many years. M. Becker (1995), in a survey of the historical literature on creativity research, found that 19<sup>th</sup> century authors tended to focus on five basic questions:

- What is creativity?
- Who has creativity?
- What are the characteristics of creative people?
- Who should benefit from creativity?
- Can creativity be increased through conscious effort?

Interestingly, similar issues have occupied creativity researchers well into the current century. However, while it is true that scholars throughout recorded history have enquired into the nature of creativity, it is also true that the period from the latter half of the 20th century to the present has seen a significant escalation in interest in creativity. Amabile (1982) cites a surge of interest in the topic of creativity in the psychology literature between 1950 (less than 0.2% of the listings in Psychology Abstracts) and 1980 (more than 1% of the listings in Psychology Abstracts). This growing interest in the topic in the psychology research community is paralleled by a swelling of interest in the topic in the general literature. The Google Ngram tool shows the following trend in the relative frequency of the word ‘creativity’ in the corpus of books digitized by Google, published between 1800 and 2000:

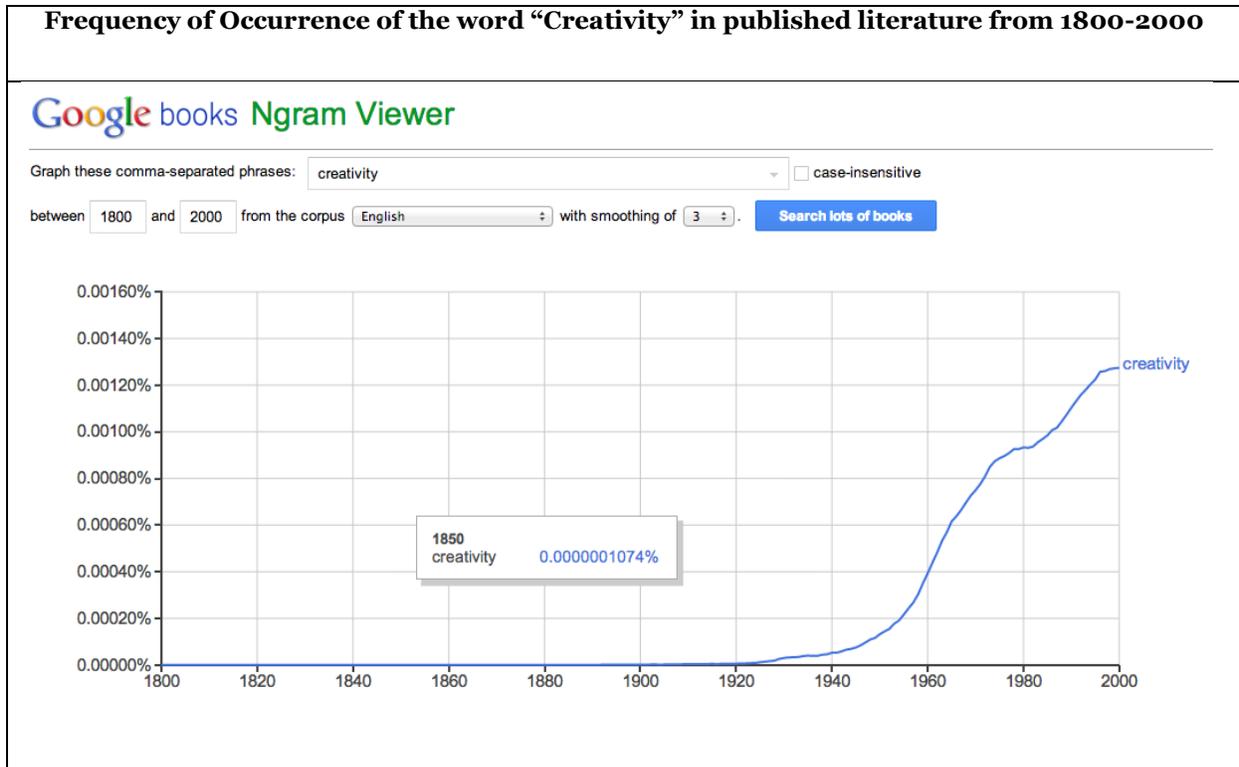


Figure 1: Mentions of “Creativity” in published works, 1800-2000

Source: (Google, 2014), retrieved 01-16-2014

The surge in apparent interest in the topic of creativity between 1940 and 1960 corresponds with some important developments in the study of creativity itself. To contextualize these developments, it is useful to look at the history of creativity as a concept, and as an object of scholarly research.

While creativity research has always been a multidisciplinary pursuit, the most influential discipline in the field (and, in fact, a key reference discipline for many of the other fields that engage in creativity research) has been the discipline of psychology. From the 1920s to the 1950s, the dominant paradigm in psychology was behaviorism. A key tenet of behaviorism was that scientists should not study anything that was not directly observable: they should confine scientific enquiry to those areas that can be directly observed and measured. This can be recognized as an empiricist axiological assumption (based on logical positivism), and that reflects the dominant thinking of the era. The major challenge to behaviorism early in the century came from Freudian psychoanalysis, which saw creative impulses as being reflections sexual frustration and neurosis (Freud, 1916). Research in psychology was limited to topics that were well suited to the dominant paradigm, such as the well-known studies of conditioning by Pavlov (1927). There was little scholarly exploration of creativity in psychology up to the 1940s.

It is widely accepted that the turning point of this lacuna in the literature was the inaugural address of J. P. Guilford as president of the American Psychological Association in 1950 (Guilford, 1950). Guilford used

his address to call for more scholarly research on creativity in psychology, and the surge of interest in creativity among researchers at the time has been attributed to that call (Amabile, 1982). However, there is reason to believe that there are a number of influences which came together at that time in order to facilitate the growth of creativity studies as an area of research. As R.K. Sawyer (2012) notes, 1950 was also the date of the beginning of the National Science Foundation in the United States, creating a streamlined system for funding researchers who were pursuing high-priority research. At the same time, creativity research became a very high priority, since it began to be seen as both a potential source of advantage in the Cold War, and an antidote for the perceived lack of innovation at large, stable American corporations (R.K. Sawyer, 2012, p. 17). A number of research psychologists who had experience developing evaluation techniques for the military during World War Two (including Guilford), now turned their attention to the creation of research institutes for the assessment and development of general aptitudes. Then there was the devastating review of (Skinner, 1957) by Chomsky (1959), which is widely viewed as a milestone in the paradigm shift in psychology away from behaviorism and toward what came to be known as cognitivism. These converging trends all had the effect of making creativity an attractive topic for researchers, and resulted in a sharp increase in the number of papers being produced in the field.

The major goal of creativity research during this period was to accomplish something similar to what had been accomplished in the field of intelligence: the development of a test, or battery of tests, that would reliably measure creative ability and predict creative potential. This would enable the selection of suitable candidates for appropriate training that would prepare the way for optimizing creative output within the society. In this, it is safe to say that this phase of creativity research was a failure. Creativity tests were created by several researchers, including Guilford, and many of them were enfolded into the Torrance Tests of Creative Function (Torrance & Scholastic Testing, 1974). However the measures developed in this phase of research displayed suspect psychometric characteristics, have had their validity challenged, and never did attain the kind of widespread acceptance that was enjoyed by popular measures of intelligence (Amabile, 1996, pp. 26-28). R.K. Sawyer (2012) notes that, in the early days of creativity research, creativity and intelligence were thought to be closely related, with many authors considering creativity to be an artifact of intelligence. More recent research has supported a “threshold theory”, which holds that creativity is associated with intelligence, up to a certain threshold value of intelligence; beyond which increases in intelligence are uncorrelated with increases in creativity. Moreover, declarative memory (for facts) and procedural memory (for how to do things) may have different – and sometimes opposing – effects on the improvisational process (Moorman & Miner, 1998).

There have also been a number of studies which use the tools of cognitive neuroscience to study creativity. The case has been made for using brain-imaging tools to explore creative processes in the brain (Abraham & Windmann, 2007). A number of studies have reported on correlates between mental events in creative processes and patterns of activation in the brain (Abraham et al., 2012; Takeuchi et al., 2011; Vandervert, Schimpf, & Liu, 2007), and addressed long-standing questions, such as the relationship between creativity

and certain forms of mental pathology (Abraham & Windmann, 2008). However, the findings of these studies must be accepted with caution. R. K. Sawyer (2011), in a critical review of the cognitive neuroscience research on creativity, pointed out several challenges associated with making inferences about real-world creativity based on brain-imaging studies. Perhaps the most serious of these is the fact that the neurological correlates of creative processes are simply that: correlates. There is no way – given the limits of current instrumentation – to demonstrate that the areas of increased activation (all neurons are constantly firing, so there is no part of the brain that “lights up” only during creativity) are directly involved in the creative process. This is an area of concern for making inferences from brain imaging studies in general. For example, judgments of Perceived Usefulness (PU) have been associated with activation in the anterior cingulate cortex (ACC) (Angelika Dimoka & Davis, 2008), but without a clear understanding of the function of the ACC, that tells us little about PU (Botvinick, Cohen, & Carter, 2004). Measurement challenges also mean that brain imaging studies must be conducted in highly controlled artificial environments (R. K. Sawyer, 2011, p. 141), creating concerns about the generalizability of their findings to real-world contexts. Overall, R. K. Sawyer (2011) concludes that cognitive neuroscience is a useful tool with a lot of promise for the study of creativity. However, its greatest contributions to date have tended to confirm the findings from previous experimental studies, rather than break new ground.

In the early days of scientific creativity research, creativity was commonly seen as an individual trait (Guilford, 1950; Isaksen & Dorval, 1993). However, more recent work has made it clear that social and group processes and influences may also play a key role in the generation of creative responses. Hargadon and Bechky (2006) propose a view that moments of creative insight emerge from interactions between individuals, rather than being the outcome of purely individual cognition. Meisenzahl and Mokyry (2011) demonstrate that, in order to make the leap from an original idea to a usable creative product, a network of microinventors (or ‘tweakers’ as per ((Meisenzahl & Mokyry, 2011, p. 5)) is often necessary, to refine and complete the idea. R. K. Sawyer (2007) proposes that most significant innovations emerge from a collaborative web: a network of actors who share information about, and contribute to, the domain of the creative product. He demonstrates that successful creative products often succeed on the basis of being able to generate rich collaborative webs, rather than the brilliance of a single inventor. This led him to conclude “collaborative webs are more important than creative people” (R. K. Sawyer, 2007, p. 185).

Uzzi and Spiro (2005) explored the effects of density of connection in social networks on creative production. They applied Milgram (1967)’s ‘Small World’ hypothesis to a highly creative group (the creators of all Broadway shows between 1945 and 1989) and found that network effects of social systems have an effect on creativity: increasing density of social networks lead to increasing levels of creativity. However the effect was parabolic: up to a point, increasing network densities have a positive effect on levels of creativity; beyond that point, this positive effect reverses: higher social network densities lead to decreasing levels of creativity. Uzzi & Spiro suggest that this effect is a result of the fact that members of groups can bring novel resources that are unfamiliar to other members of the group and can serve as

resources for the creative process within the group (Uzzi & Spiro, 2005, p. 47). However, as groups become more connected, the likelihood increases that the information that each member brings to the creative process will already be known to other members of the group, reducing the value of the contribution of each member. R. K. Sawyer (2007) proposes another mechanism by which group heterogeneity may stimulate creativity that may be undermined by excessive group cohesiveness. The process of communicating information between group members that have different backgrounds and conceptual systems may necessitate creating analogies which facilitate set-breaking and start the creative process. As groups become more closely connected, they develop shared understandings which reduce the need to deconstruct information in order to communicate.

The goal of a standardized measure of creativity remains elusive, but the past several decades of research have led to the development of a significant corpus of knowledge about creativity. More recent work has both drawn on, and extended, this body of knowledge. Current evidence suggests that creativity is a “network” phenomenon, that emerges from a complex mix of factors such as access to resources, social network access, and environmental factors (R. K. Sawyer, 2007; A. Taylor & Greve, 2006; Uzzi & Spiro, 2005). This makes it more unlikely that the original goal of a simple “I. Q.”-style standardized measure for creativity will ever be feasible.

Rather than a single dominant paradigm for the study of creativity, there are now several different approaches that are used by different researchers in different domains. In the sub-sections of this section, I will look at different families of approaches that have been used to attempt to understand creativity and the creative process. I will look at Finke et al. (1992)’s cognitive approaches which have been used in experimental work to understand creative processes in the individual mind at the individual level. I will then look at the Csikszentmihalyi (1999a)’s system approach, which has been used to analyze creativity at the collective level. I will then look at one of the approaches that has attempted to achieve synthesis by analyzing creativity at both the individual and collective levels, while providing concepts for understanding how each level influences the other, that is, Amabile (1983)’s componential model.

### **2.3.2 Definition**

Creative appropriation is distinguished by the quality of being creative. In order to address the nature of creative appropriation it is first necessary to speak to the nature of the concept of creativity. What is creativity? Is it the generation of anything new, or does a creative act need to meet certain criteria in order to be recognized as ‘creative’? How can creativity be recognized? How can it be measured? These questions outline the essence of the ‘criterion problem’ in creativity research (Amabile, 1982, 1996): without a clear and unambiguous definition of creativity, we run the risk of losing track of what we are studying. In order to explore creativity, we must first define it.

Sternberg and Lubart (1993) define creativity as the ability to produce work that is both novel and appropriate. It is worth mentioning that the definition of ‘work’ in this context is any creative output such as a physical object (a painting), an idea (a theory) or a script (a method of attaining a goal). Boden (1996) defines it as the ability to create ideas or combinations of ideas that are “new and interesting”. Kneller (1965) called creativity the discovery and expression of something that is both new to the creator and an achievement in its own right. The plethora of available definitions for creativity creates a fundamental problem for creativity researchers. As has been noted by (Benbasat & Zmud, 1999) in the context of IS research, in order to develop a cumulative body of knowledge about a phenomenon it is helpful to have a common definition of what it actually is. Creativity researchers have been repeatedly criticized for ‘not knowing what they are talking about’ (Amabile, 1996), and the proliferation of similar – but slightly different – definitions of creativity in different streams of research has led to the development of independent bodies of literature with little integration.

While there are many competing definitions of creativity in the scientific literature, they all tend to share the characteristics of novelty and appropriateness-for-purpose (Amabile, 1983). For example, (Sternberg & Lubart, 1993) define creativity as the ability to produce work that is both novel and appropriate. It is worth mentioning that the definition of ‘work’ in this context is any creative output such as a physical object (a painting), an idea (a theory) or a script (a method of attaining a goal). Boden (1996) defines it as the ability to create ideas or combinations of ideas that are “new and interesting”. (Kneller, 1965) called creativity the discovery and expression of something that is both new to the creator and an achievement in its own right. These definitions share two important characteristics:

- Novelty: The output of the creative process must in some way be new.
- Appropriateness: While it is often trivial to make or do something differently from its precursor, the label of ‘creative’ assumes that the outcome is appropriate for some purpose

There is also another quality, which Boden (1996), for example, labels “surprising”. While most people do things on a regular basis which are novel to them, and those things may be appropriate for some purpose, not all novel things are creative. Creative products or actions have a particular quality which can be recognized, by persons familiar with the domain, as creative (Amabile, 1982).

Stein (1953) defined creativity as “*that process which results in a novel work that is accepted as tenable or useful or satisfying by a group at some point in time*”. This definition incorporates a number of elements which can form a foundation for developing a conceptual definition of creativity. Some of the more important elements are:

1. *Creativity as a process, rather than an event* – creativity is sometimes represented as a flash of insight, or a “Eureka!” moment. Though the phenomenon of moments of insight is an important part of many accounts of creative discovery, research indicates that creativity is more likely to be

the result of sustained effort on the part of the creative actor (Ericsson, Krampe, & Tesch-Römer, 1993). Even ‘spur of the moment’ ideas typically occur to those who have been prepared for them by considerable information-accumulation in the domain of the idea (Csikszentmihalyi, 1997, 1999b; Fisher & Amabile, 2009).

2. *Creativity can be recognized by its output* – one of the perennial difficulties of the study of creativity is the isolation and identification of the phenomenon of interest (Amabile, 1996). Though significant work has been done on the cognitive and neurobiological processes involved in creativity (A. B. Kaufman, Kornilov, Bristol, Tan, & Grigorenko, 2010a; T. B. Ward, Smith, & Finke, 1999), it is not yet possible to recognize ‘creative’ processes in the brain by their physiological characteristics. Some theorists, such as Barron and Harrington (1981), argue that some definitions of creativity assume creativity itself to be valuable. As such, under those definitions, dreams, unexpressed thoughts or imaginativeness may be seen as creative. While this may be so, it remains a fact that the limitations of current methodologies mean that such creative acts must be expressed or demonstrated before they can be recognized and empirically studied – and the expression of them does meet the definition of ‘product’ as it is used in the literature. The most commonly accepted method for recognizing creative processes, therefore, is the retrospective observation that the process has produced a ‘work’ (Stein, 1953) that is creative.
3. *Creative output must be novel* – there are numerous examples of creative discoveries or achievements being attained simultaneously by non-collaborating individuals (Merton, 1961). While for historical and legal purposes the order of those inventions or discoveries may be significant, each of them may provide some insight into the creative process. However, by definition, the domain of creativity is concerned with the generation of output that is new; if not to the world, at least to the individual (Boden, 1996).
4. *Creative output must meet some threshold of appropriateness and quality in order to qualify as creative* – it is also a part of the definition of creativity that the creative product cannot simply be new – it must also meet some standard of quality in order to be accepted as truly creative
5. *The appropriateness and quality of creative output is assessed by a group* – there is, at this time, no comprehensive set of objective criteria that can be applied to all products in all domains in order to assess them for creativity (Amabile, 1996). Although the qualities of ‘novelty’ and ‘appropriateness’ are widely accepted in the literature, they are not sufficiently specific to be usefully applied to real-world products. In order to apply them, is necessary to develop a set of criteria for the product that defines the nature of novelty and appropriateness in its domain. That process, to be objectively done, depends on social consensus
6. *Creativity is contextually and temporally specific* – when a group makes a determination about the novelty and appropriateness of a creative product, they do so using a set of values and criteria that are specific to their circumstances. For example, Csikszentmihalyi (1997) cites the example of van Gogh, who died alone and penniless, and whose work was considered by many of his contemporaries to be the valueless scribbles of a madman – and thus, by the criteria of

appropriateness and quality – uncreative. After his death, other individuals judged his work to be highly valuable and of great quality – thus rendering them ‘creative’. There are numerous other examples in history of products being rated as highly valuable in one context or era, but reevaluated as being of little value in another, or vice versa.

Different creativity theorists have attempted to deal with the ‘criterion problem’ in different ways. Simonton (1989) used computerized content analysis of the output of musicians to test a theory of late-lifespan creativity. He used an algorithmic approach to statistically analyze the final works of several composers for such qualities as melodic originality and melodic variation. While this method holds the promise of applying a truly objective test of creativity, it has two important caveats that limit its usefulness in general creativity research. The first is that many domains in which creativity can be exercised do not have dimensions which can be expressed mathematically without a corresponding loss of information which reduces the ability of a rater to evaluate the quality of the work. The second – and related – problem with Simonton (1989)’s method is that it is incapable of differentiating – without the intervention a human rater – between the truly original, and the simply bizarre (Amabile, 1996). In the case of Simonton’s work, his sample consisted of classical composers whose work had already been assessed as both novel and appropriate for the domain of classical music. However, there does not exist, at this time, an algorithmic approach that could have reliably made that assessment without human judgment.

To further examine the conceptual issues that exist in the definition of creativity, I will consider examples from three different research streams. One stream approaches creativity by looking at the individual characteristics of, and cognitive processes in the minds of, individuals involved in creative tasks. Another stream looks at the interaction of different social structures within knowledge domains to explain the processes that result in creative production within those domains. The third looks at creativity as an outcome of the interaction of different components at both the individual and collective levels.

### ***2.3.2.1 An Individual Approach***

This approach holds that the properties of creative individuals are primarily responsible for their creative outputs. In this case, “properties” is being used broadly, to represent both the characteristics of individuals, and the actions of those individuals. Under the assumptions of this stream, differences in creative outputs are largely due to differences in the properties of the individuals generating those outputs.

The element of the individual stream that focuses on individual differences is largely modeled on the work on intelligence which grew out of selection testing methods developed in World War II. The goal of this stream of research was largely to develop a suite of tests which – like IQ tests – easily identify the most “creative” members of a given group. The adoption of this perspective implies that creativity is best

explored by discovering the unique characteristics that enable people to generate creative output. This lead to the development of creativity tests (Torrance & Scholastic Testing, 1974), biographical inventories (C. W. Taylor & Ellison, 1968) and personality tests (Gough & Heilbrun, 1983), aimed at measuring creative ability. However, efforts to measure creativity using these tools have generated unsatisfactory results (Hocevar, Bachelor, Glover, Ronning, & Reynolds, 1989). They have failed to demonstrate concurrent and predictive validity as well as well as failed to show convergent validity when considered together (Amabile, 1996). Also, despite seeming to offer an objective view of innate creative ability, they do not avoid the view that analyzing creative products represents the best way to investigate creativity as performance on a creativity test is a ‘product’, and the scoring of many tests is, ultimately, subjective.

Another type of research within the individual stream looks at cognitive activity, rather than individual characteristics. This type of research assumes that understating mental operations within the mind of an individual while they are carrying out creative tasks is the key to understanding creativity. This type of research is exemplified by the Geneplore model developed by (Finke et al., 1992; T. B. Ward et al., 1999).

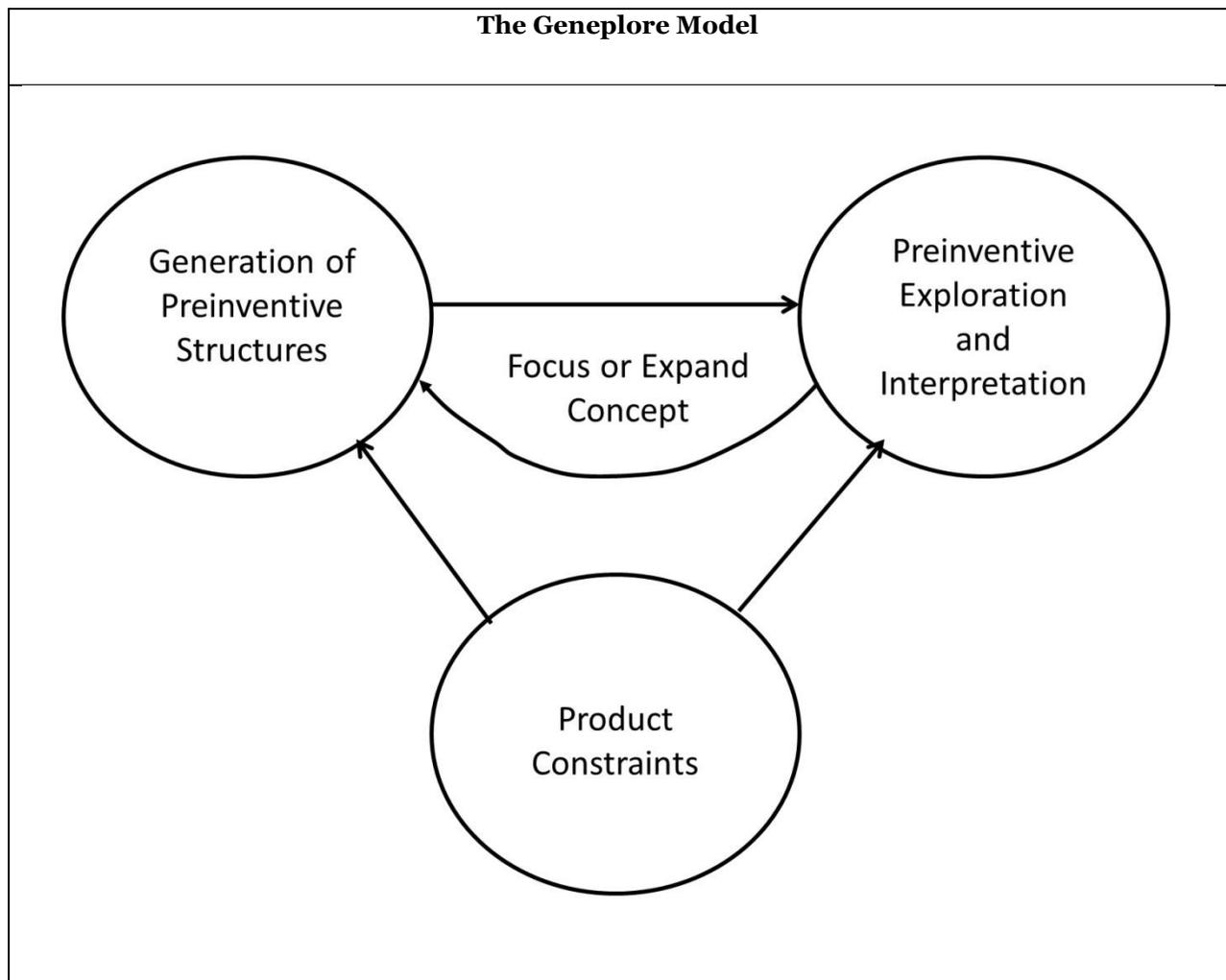


Figure 2: The Geneplore Model

This is a model of the actual cognitive process of developing a creative idea.

In the first phase (the **Generative** phase) the creative actor generates mental models known as preinventive structures. The generative process involves

- Generative processes include
  - Memory retrieval
  - Association
  - Mental synthesis
  - Mental transformation
  - Analogical transfer
  - Categorical reduction

These structures generated have certain characteristics, such as

- Novel patterns
- Object forms
- Mental blends
- Category exemplars
- Mental models
- Verbal combinations

Preinventive structures share qualities such as novelty, ambiguity and implicit meaningfulness.

The second phase of the creative process as modeled by the Geneplore model is the **Exploratory** phase. In this phase the preinventive structures that were generated are evaluated using a set of processes such as

- Attribute finding
- Conceptual interpretation
- Functional inference
- Contextual shifting
- Hypothesis testing
- Limitation searching

This process of preinventive exploration and interpretation feeds back into the generation of new and more appropriate preinventive structures. Both these processes are moderated by the constraints allowed on the end product of the creative process.

It will be noted that the processes listed are largely individual mental processes.

Preinventive structures are internal representations and may be largely uninterpreted at the time they are constructed. Properties of preinventive that are exploited in creative search and exploration include:

- Novelty
- Ambiguity
- Implicit meaningfulness
- Emergence
- Incongruity
- Divergence

People may engage in creative cognition that generates preinventive structures that exhibit these properties, or noncreative cognitions that do not. Cognitions that display more of these properties, or display them to a greater extent, are “more creative” than others. There is no explicit criterion which defines ‘creative’ v. noncreative cognitions. They lie on a continuum. For Finke et al. (1992), the ‘creativity’ of the cognition is separate from that of the idea produced – that is, they do not use a product definition. This is necessary in their model because a ‘creative’ idea could be arrived at resourcefully or accidentally. They therefore observe a *process* definition.

They do, however, talk about evaluating creative products. Some of the important properties of creative products are

- Originality
- Practicality
- Sensibility
- Productivity
- Flexibility
- Inclusiveness
- Insightfulness

They state their goal as finding ways in which to help people think in ways which are more likely to result in creative outcomes, rather than attempting to predict creativity. They contrast this with work on problem-solving, which tends to focus on finding procedures or algorithms which guarantee a correct solution.

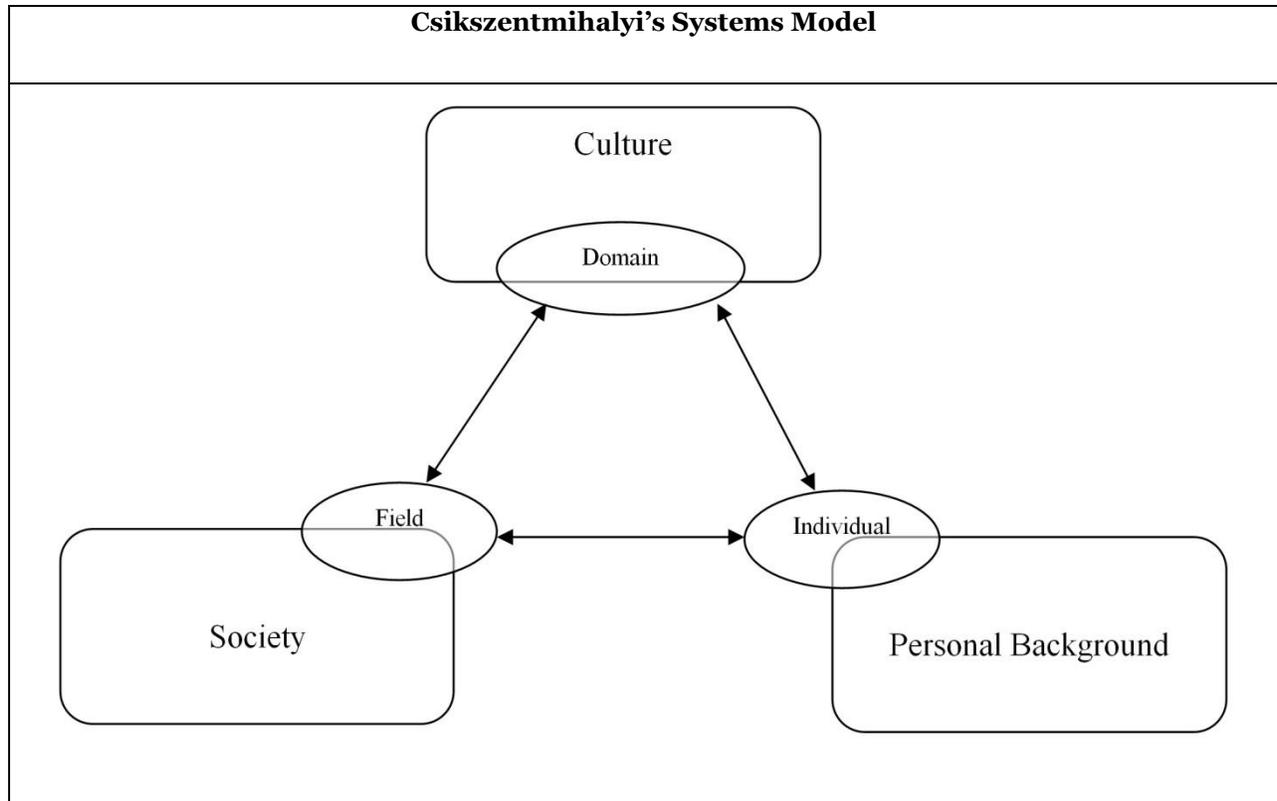
Individual approaches to creativity have contributed significantly to understanding of the processes involved in individual ideation. However the definitions of creativity commonly applied in lab studies can appear to have little applicability to real-world contexts (Gopnik, 2013). They do, however, tell a part of the story.

### **2.3.2.2 A Systems Approach**

Csikszentmihalyi (1999b) defines creativity as a system phenomenon rather than an individual behavior. According to Csikszentmihalyi, creativity is a phenomenon that emerges through the interaction of three elements:

- A *domain* – a symbol system containing information that comprises a corpus of knowledge about an area of endeavor. The domain contains both information that represents the current state of the art within the area, and rules for the evaluation of possible contributions to the domain. The domain is part of the culture: the body of knowledge within the wider society.
- An *individual* – a human actor that learns the information contained in the domain, then extends or alters that information by proposing or making changes to the contents of the domain – thereby generating a novel product within the confines of the domain. The individual’s capability and motivation to generate novelty is determined, in part, by her personal background.
- A *field* – a social system that uses the rules of the domain to evaluate products generated by the individual for appropriateness for inclusion in the domain. If the field approves the product, then the product becomes part of the domain and becomes – according to the definition – ‘creative’. The field is a social community within the society.

In this model creativity is a complex outcome – a *syndrome* (Runco, 2004) – that occurs through the interaction of each of these elements. It can be represented as:



**Figure 3: The Systems Model**

This definition incorporates the myriad social, political and interpersonal factors and processes that may be involved in the recognition and attribution of creativity, apart from the appropriateness and novelty of the product. A vivid illustration of the effect of these processes can be seen in the story of Douglas Prasher (Benderly, 2009). In 2008, the Nobel Prize for Chemistry was awarded to three scientists for the development of Green Fluorescent Protein, a marker molecule that is used to let biochemists ‘watch’ intracellular processes. The molecule in question was actually developed by Prasher, who gave the gene sequence to the Nobel laureates. However, he subsequently lost his job as a scientist and was working as a bus driver at the time that the Nobel committee was considering the list of potential awardees. Perhaps unsurprisingly, since Nobel laureates are expected to “have distinguished careers,” and “continue to have distinguished careers” (Benderly, 2009); Prasher’s work was not recognized by the committee<sup>1</sup>. Schaffer (1994) and Stigler (1980) have noted that the phenomenon of historical attribution of creativity is often fraught with error and misattribution. This implies that ‘creative’ outcomes must be seen as the result of a complex set of processes, rather than a purely individual achievement.

A creative act, using this definition, is one that is generated by the person, who, having internalized the symbols and rules of the domain, changes them, and then has that act accepted for addition to the domain

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<sup>1</sup> Prasher was given credit for the discovery by his former colleagues and today is a working scientist.

by the field. This definition stands in contrast to the definition used by scientists looking at cognitive process models of creativity (A. B. Kaufman, Kornilov, Bristol, Tan, & Grigorenko, 2010b), who tend to use performance on generative tasks or tests of creativity such as the Torrance Tests of Creative Thinking (TTCT) (Torrance & Scholastic Testing, 1974) to measure the concept. In part, this reflects the methodological constraints of such research. It is not practically possible to take continuous fMRI measurements of a scholar or scientist engaged in an innovative project that may take decades to come to completion. However, the deeper question is whether creativity is more correctly seen as a social system phenomenon – an outcome that results from the interaction of various social structures and the individual; or a cognitive act – a particular expression of a cognitive process which is influenced to some degree by external factors.

A closer look at the experimental research, however, reveals that even this class of creativity exploration cannot be seen as completely independent of the dynamics of domain and field. If creativity is to be measured by observing brain activity during a creative act, the determination must be made that that act is creative. If this is done using a test of creative thinking such as the TTCT, why do we assume that what the test measures is actually creativity? The answer is that the theory behind the tests was developed by a researcher (person) whose published results were subjected to peer review (field). When the theoretical foundation of the tests was accepted, the results of the tests became accepted as measures of the concept (domain) of creativity. Even at the level of the individual participant in the study: a participant's (person) performance on the test is evaluated by experts in reading the test results (field) and ranked using the rules of TTCT test (domain).

### **2.3.2.3 Componential Approach**

Amabile (Amabile, 1982, 1983, 1988, 1996; Amabile, Conti, Coon, Lazenby, & Herron, 1996; Amabile & Gryskiewicz, 1987; Fisher & Amabile, 2009; Hennessey & Amabile, 2010) proposed an influential model of creativity based on *components*. Those components are abstract, and they explain creativity at both the individual and collective (organizational) levels.

The overarching finding of Amabile's research is that creativity, at all levels, results from the intersection of three components: Resources, Techniques, and Motivation (Amabile, 1988).

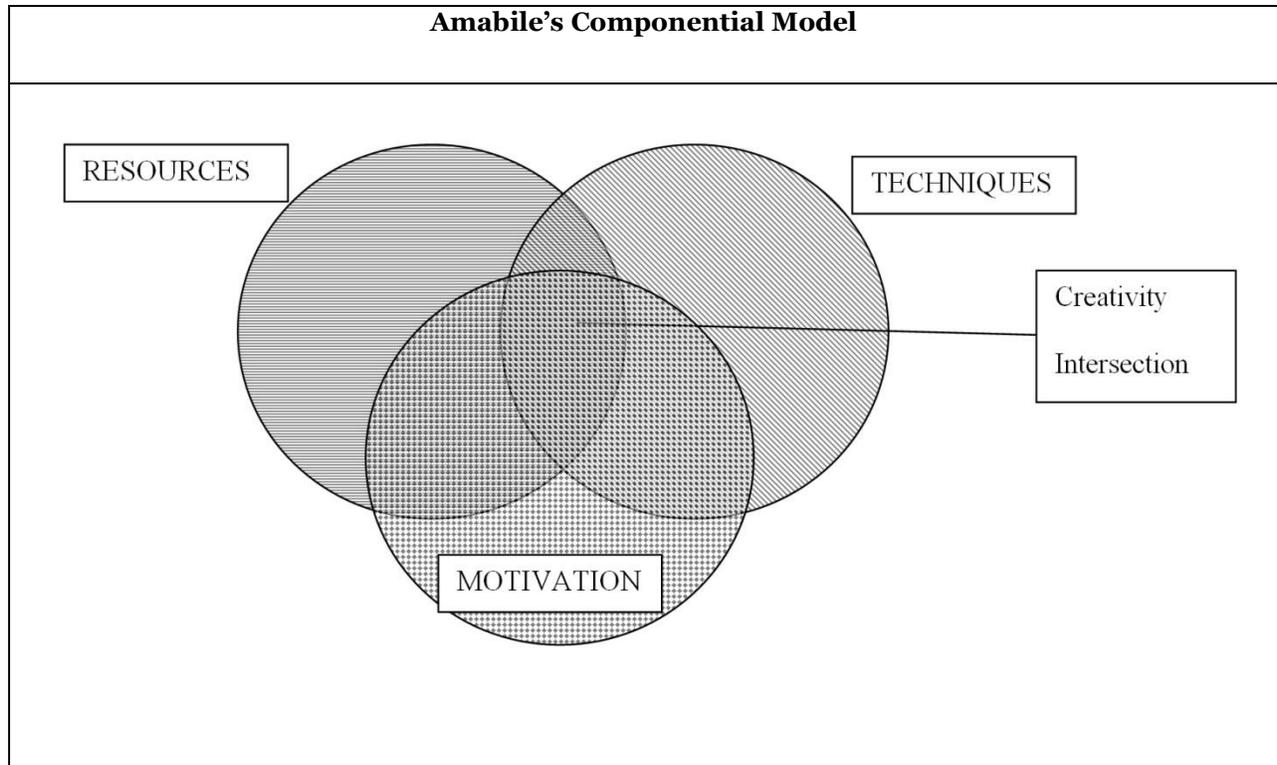


Figure 4: The Componential Model

Adapted from (Amabile, 1988)

Figure 4.1 outlines the central elements of the componential theory of creativity, as described in (Amabile, 1988). It is a comprehensive theoretical model that seeks to explain both the intrapersonal and environmental influences on creativity. According to Amabile, there are three general components to creativity at both the individual and organizational levels. However, at each of those levels, the specific components differ. The three components, and their specific instantiations at the individual and organizational levels, are:

- **Resources**, which represent the raw material required for creativity in a domain.
  - At the *individual* level, resources are represented by the component: Domain-Relevant Skills such as factual knowledge about the domain, necessary technical skills and special talents that are relevant to the domain
  - At the *organizational* level, resources are represented by the component Resources in the Task Domain: everything that the organization has available to aid work in the task domain. This can include providing adequate resources for employees, and creating conditions in which employees will have realistic amounts of workload pressure
- **Techniques**, which represent the skills necessary to perform creative work in a domain.

- At the *individual* level, techniques are represented by Creativity-Relevant Skills, including a cognitive style that is conducive to creativity, the ability to apply heuristics for generating ideas, and a work style conducive to creativity
- At the *organizational* level, techniques are represented by Management Practices; such practices as allowing an appropriate balance between freedom and constraint, setting employee tasks which are well matched to levels of ability – thereby giving the right level of challenge to employees, encouraging employee creativity, and creating a work environment conducive to creativity
- **Motivation**, which represents the drive to innovate which is the catalyst for creativity.
  - At the *individual* level, motivation is represented by Task Motivation: attitude toward the task, and perception of one's own motivation to perform the task – whether one perceives oneself to be motivated to innovate by external reward, or an inner positive affective response to the task
  - At the *organizational* level, motivation is represented by Motivation to Innovate: the basic motivation of the organization to innovate as matter of policy, including supporting creative action by employees, and removing impediments to creativity such as inappropriate reward structures

Of the three components to creativity, the most important is motivation (Amabile, 1988, 1996). For an individual, one's level of resources will determine if one is able to be creative in a domain, one's available techniques how one is able to be creative, but one's level of motivation whether or not one makes the attempt. Amabile (1996) emphasizes the importance of the social environment in determining one's level of motivation. Therefore, elements of the components of creativity at both the individual and organizational levels will be used to generate a set of a priori constructs for this study (Eisenhardt, 1989a). These initial constructs are listed in Appendix 1.

#### **2.3.2.4 Creative Appropriation: A Definition**

One of the perennial difficulties encountered in field studies of creativity is the criterion problem – the difficulties encountered in defining whether an idea or product is 'creative' (Amabile, 1996, p. 19). No standardized method for assessing creativity across all domains currently exists, and individuals are notoriously unreliable judges of the creativity of their own ideas (Csikszentmihalyi, 1997). Further, different individuals may have different assessments of creativity in a domain, depending on their level of understanding of the criteria for assessing creativity in a particular domain. The most common definitions of creativity in current use draw on a consensual assessment of the creative product by independent, appropriate observers. The most commonly-cited technique for applying this consensual judgment is the Consensual Assessment Technique (CAT), commonly attributed to Amabile (1982), (see (Hennessey & Amabile, 2010)), although R.K. Sawyer (2012, p. 41) attributes it to Csikszentmihalyi (1965). It proposes that since it has proven impractical to develop domain-general objective criteria for rating creative

products, creativity should be recognized based on consensus judgment: an idea or product is creative to the extent that appropriate observers agree it is creative. The CAT has been widely used in studies in a number of domains (S. Lee, Lee, & Youn, 2005), and will be adopted here.

In light of the preceding, the operational definition of creative appropriation which will be applied in this study is

*An instance of individual-level creative appropriation is an incident in which a user appropriates a system in novel way to perform a task, where such method of appropriation is independently judged creative by appropriate observers.*

Amabile acknowledges the role of communication as a critical part of the ‘Response Validation’ step at the end of the creative process (Amabile, 1996, p. 114). However, more recent work has made it clear that in real-world creativity, social and group processes and influences may also play a key role in the generation of creative responses at multiple stages (Nijstad & Stroebe, 2006; R. K. Sawyer, 2007; Uzzi & Spiro, 2005). Also, a creative idea about how to use a system may originate with a user who does not have the technical skills to complete its implementation without collaboration. This implies that in order to understand the creative appropriation process, it will be necessary to understand collective-level processes in the accounts of appropriation studied. While it is beyond the scope of the thesis to fully explain these collective-level processes that are external to the individual, it is impossible to explain individual level appropriation without including collective level processes in the account. This requirement will be addressed during research design.

Miles and Huberman (1999) state that an initial conceptual framework can form an important initial component of a study by identifying the main things to be studied, outlining key factors, constructs and variables, and identifying the presumed relationships among them. As such, the definition from Amabile (1982) will form a foundation for the work, and will not only assist in identifying the object of the study, but provide a framework for its measurement.

### **2.3.3 Creativity Research in IS**

Both creativity and IT appropriation have received attention in the prior IS literature. IT appropriation, with various labels such as “system use” and “system utilization”, has received substantial attention; creativity, much less. However, authors addressing each concept have suggested that universally applicable ‘covering law’ type theories which address every real-world instance of the phenomenon are not a realistic goal for field research in either domain. Burton-Jones and Straub (2006) state that system use cannot have a single conceptualization across contexts and that diverse conceptualizations are desirable, a conclusion echoed by McLean et al. (2011). For creativity, Dreyfus (2009) argues that

unconstrained research on creativity in general appears to be too unfocused to be useful, and it is generally accepted that individual creative ability tends to be domain specific (S. B. Kaufman, 2009).

Couger et al. (1993), calling creativity a “neglected area” in IS research, and the current level of such research in the field “embryonic”, conducted six case studies in which creativity techniques were brought to bear on problems within an IS framework in organizations. The case studies demonstrated the beneficial effects of formal techniques for fostering creativity on IS operations. Couger et al. (1993) also report several other instances of success using such formal creativity techniques in successfully in other IS contexts. These findings suggest that a greater emphasis on creativity may be of benefit to the IS function in organizations. However, Couger (1990) also may suggest some issues which may be salient in attempting to evaluate the IS-related creativity literature and assess the current role of the concept of creativity in the IS field. These are a somewhat narrowly defined scope for the application of creativity within IS, and a need for a broader conceptualization of creativity in order to recognize more levers of creativity within the IS function. One notable feature of the case studies reported in (Couger et al., 1993) is that all the listed examples of the exercise of creativity occur in the problem-solving context. In fact, several of the techniques listed: abstraction, interrogatories (who-what-when-where-why and how), use of analogy/metaphor, etc. are commonly accepted as problem-solving techniques. Creativity is often recognized as an aspect of problem-solving, but most definitions of creativity conceptualize it more broadly. Creativity studies in IS, however, have tended to look at creativity in limited contexts.

Seidel et al. (2010) conducted a comprehensive review of research on creativity in the IS discipline over the period 1977-2009. They performed a search for the term ‘creativity’ in the title, abstract and keywords of all the articles in the eight leading journals in the field of Information Systems. This search retrieved 27 relevant hits out of 5,459 articles, or 0.49% (Seidel et al., 2010). An analysis of the topics covered in the papers found in this review follows:

**Table 1: Articles on Creativity in IS Literature**

<b>Article</b>	<b>Main Topic Summary</b>	<b>System Development</b>	<b>Creativity Support Systems</b>
(Aaen, 2008)	Facilitating creativity and innovation in software development.	✓	
(Avital & Te'eni, 2009)	How IT-based systems can be designed to facilitate generative capacity in users	✓	
(Cooper, 2000)	IT-enabled organizational reengineering strategies		
(Couger et al., 1993)	Techniques for improving creativity that can be applied in the IS field		
(Datta, 2007)	A model for the use of agents as mediators in knowledge management		
(Dean, Hender, Rodgers, & Santanen, 2006)	Developing scales for evaluating the quality of creative ideas		
(Dennis, Daniels Jr, Hayes, & Nunamaker Jr, 1993)	Case study of an application of a BPR modeling tool		✓
(Easton, George, Nunamaker Jr, & Pendergast, 1990)	Comparison of the performance of two Electronic Meeting System (EMS) software packages		✓
(Elam & Mead, 1990)	Exploration on the effect of a DSS designed to enhance creativity on creative output		✓
(Garfield, Taylor, Dennis, & Satzinger, 2001)	Evaluation of how groupware-based creativity techniques influence types of ideas generated		✓
(Hender, Dean, Rodgers, & Nunamaker Jr, 2002)	Evaluation of how groupware-based creativity techniques influence types of ideas generated		✓
(H. Lee & Choi, 2003)	Testing the effect of knowledge management strategies		
(Lee-Partridge, Teo, & Lim, 2000)	Case study of the use of IT in the Port of Singapore Authority		
(Lilley, 1992)	Exploration of the effects of EIS on executive creativity		✓
(Massetti, 1996)	Test of the effectiveness of two popular Creativity Support Systems		✓
(Massetti, 1998)	A response to a methodological critique of the Massetti (1996) study		✓
(Nagasundaram & Bostrom, 1994)	A framework for evaluating the idea generation performance of Group Support Systems (GSS)		✓
(Nunamaker Jr, Applegate, & Konsynski, 1987)	Exploration of the effect of GDSS on group creativity		✓
(Ocker, Hiltz, Turoff, &	A comparison of the effects of asynchronous computer conferencing vs. face-to-face communication on the	✓	✓

Fjermestad, 1995)	creativity of software development teams		
(Ocker, Fjermestad, Hiltz, & Johnson, 1998)	A comparison of the effects of four different modes of communication on the creativity of software development teams	✓	✓
(Santanen, Briggs, & Vreede, 2004)	A test of the efficacy of the cognitive network model (CNM) on creativity output		
(Satzinger, Garfield, & Nagasundaram, 1999)	An exploration of the effect of group memory as encoded in a Group Support System influences the type of ideas generated by the group		✓
(Schenk, Vitalari, & Davis, 1998)	An analysis of the differences in how novice and expert system analysts approach requirements analysis	✓	
(Shepherd, Briggs, Reinig, Yen, & Nunamaker Jr, 1995)	A study of electronic brainstorming (EBS) tools and techniques		✓
(Tiwana & McLean, 2003)	A study of how integration of individually held expertise leads to team creativity in information systems development (ISD) teams	✓	
(E. S. Weber, 1986)	A paper on how decision support system design ought to facilitate creativity		✓
(Wierenga & van Bruggen, 1998)	A methodological critique of (Masseti, 1996)		

Of the 27 studies found by Seidel et al. (2010), six concerned issues related to software or system development, and creativity on the part of systems designers and implementers. Fifteen looked at user creativity while using creativity-facilitation systems, such as Decision Support Systems (DSS) or Creativity Support Systems (CSS). Overall, 19 of the 27 studies found by Seidel et al. could be classified as addressing one or both of those problem domains (two of the studies could be classified as addressing both domains). If we eliminate the study which was a methodological critique of another study (Wierenga & van Bruggen, 1998), and the paper which was a response to that critique (Masseti, 1998), we find that Seidel et al. (2010) found only six studies related to creativity in the IS field which did not address system development or CSS use over a period of 32 years.

It is possible that the findings of Seidel et al. (2010) may, in part, reflect IS researchers' studying creativity-related topics using terms other than "creat---". Wehner et al. (1991) found in a review of dissertations in economics, sociology, psychology, education, business, history, history of science, political science and other fields, that scholars in different disciplines tended to use different terms – and focus on different aspects – of the same basic phenomenon of creativity. The IS discipline makes extensive use of concepts and theories from various reference disciplines (Benbasat & Zmud, 2003), and it is possible that that the chosen methodology may have resulted in some under sampling of the IS-related creativity literature. It is also true that IS-related research may be published in non-IS journals (see (Te'eni, 1989)). Yet there is more evidence that the topic of creativity is under-researched in IS. Couger et al. (1993) found

only six papers in IS which discussed creativity at any length, compared to over 4,000 publications in engineering, science, education, architecture and psychology.

From their review of the creativity literature in IS, Seidel et al. (2010) made several findings and recommendations for the future of creativity research within the field. Among their findings, they found that the Person and Press perspectives from the (Rhodes, 1961) model were underrepresented in IS studies. This is notable in light of the fact that these perspectives have been shown to be highly relevant in determining creative output (Amabile, 1983; Csikszentmihalyi, 1999a). They also found that few studies looked at the organizational level of analysis and no studies considered the market level of analysis. They found that, according to Orlikowski and Iacono (2001)'s conceptualization of the five 'views' of the IT artifact, only the tool, ensemble and nominal views appeared in the research. The proxy and computational views were not represented. They also found a prevalence of variance theories, reflecting a possible reductionist approach to the complex phenomenon of creativity.

Among their recommendations for future research on creativity in IS were a richer conceptualization of the IT artifact, rather than the 'black box' conceptualization common in the studies they review. They also recommend an exploration of the impact of perceptual, cognitive, and affective responses to the IT artifact on individual creative processes. They also call for more qualitative in-depth research into IS and creativity that can lead to a deeper understanding of the socio-technical contexts within which IS interacts with and enables creative processes.

From the limited number of studies available, some general trends in the treatment of creativity in IS can be gleaned. First, creativity studies in IS tend to focus on the exercise of creativity by system designers (e.g. (Aaen, 2008)), the performance and effectiveness of creativity-support systems (e.g. (Garfield, 2008)) or both (e.g., (Ocker et al., 1995)). The role of creativity in the interaction of users with systems outside of the contexts in which facilitating user ideation is an explicit goal of the interaction seems under-researched. Second, the Rhodes (1961) 4-Ps classification model is possibly the most widely-cited theoretical model of creativity in IS studies, though some of the classes are underutilized. Thirdly, the conceptualization of creativity in IS research does not seem to have been explored in as great depth as examinations of creativity in other fields. For example, creativity in IS articles is usually portrayed as a desirable goal. However, creativity on the part of users can have negative implications in terms of IT risk (Westerman & Hunter, 2007), and the ethical side of creativity is an area of active debate in other fields (Cropley, Cropley, & Kaufman, 2010).

#### **2.3.4 Implications for IS**

Creativity is a vibrant area of research in many fields, with research interest focusing both on its nature and structure as well as its antecedents and effects. However in IS, relatively few studies have addressed

the topic of creativity, despite repeated calls for more research on subject, and despite the fact that creative action is an element of many other topics which have received more attention in the literature.

The question being addressed in this section is, why should this gap in the literature exist? There have been repeated calls for more focus on creativity, and the IS discipline seems ideally positioned to do the kind of integrative multidisciplinary research that has been called for in the area of creativity research. Why has this call not been heeded?

Based on the review of literature conducted in the previous sections, I will suggest one possible explanation.

As I noted in the earlier section of this review that focused on system utilization, there are two major streams of research that can be distinguished in the IS discipline. There is a nomothetic stream that is dominated by extensive studies that utilize statistical modeling, in which use is often represented using standardized constructs which are efficient at representing general measures of utilization as a quantity, but reductionist in terms of the information they capture about the nature of that utilization. There is also an idiographic stream that is efficient about capturing rich information about the nature of utilization within a specific context, but weak in terms of generalizability across contexts, making it difficult to accumulate knowledge across studies and contexts (Moore & Benbasat, 1991). This means that creativity – particularly user creativity in the sense of developing new and unexpected ways to apply systems – is not well suited to being represented by either of the two major representational schemes that are dominant in IS. Viewing utilization as a quantity does not capture details of how and why users change their use patterns. However, as noted by Moore and Benbasat (1991), without common constructs and measures it is difficult to explore the common elements of user behaviors that may be involved in developing new appropriation patterns. End user creativity appears to fall into a gap in the representational strategies provided by the major paradigms of IS.

The way in which people use IT systems in the modern world is rapidly changing. The methods provided by the dominant approaches have been very efficient at enabling IS researchers to accumulate knowledge about systems which essentially automate recurring processes, while providing a way to investigate “interesting cases” through intensive, contextually-specific means. With the changing nature of IT and the fact that it is now becoming more and more integral to the way people live and work, these metaphors are becoming insufficient. It is becoming necessary to represent users’ detailed interactions with IT, as well as the cognitive and social processes that are intrinsic to those actions. This is what is driving the current surge of interest in new ways to represent IT interactions, and it likely what explains why, despite the apparent value of the topic, little work on creativity has occurred in the IS discipline up to this point.

In the next section, I will review an area within the behavioral sciences which will provide key lenses that will be used in this study to understand human creativity.

## 2.4 Cognitive Science

Cognitive science has been defined as “the interdisciplinary study of mind and intelligence, embracing philosophy, psychology, artificial intelligence, neuroscience, linguistics, and anthropology” (Thagard, 2012). It is, as the definition suggests, an exceptionally broad field, with a domain of content spanning the biological mechanics of brain operations, through to the philosophical issues of the nature of mind, thought, and being.

Philosophical enquiry into the nature of mind has a history that extends back to the Greek philosophers and beyond. Metacognition — thinking about thinking — is a perennial topic in both the scholarly and popular literature. However, the field of cognitive science is understood as having its origins in the mid-to-late 1950s. While the field is very broad, it has at its center a set of common metaphors and conceptualizations. Conceptually, cognitive scientists approach the mind as a machine (Boden, 2006). Specifically, they use a computational metaphor to represent the operations of the mind at an abstract level. The implications of the breadth of cognitive science are sometimes not appreciated. For example, cognitive science is sometimes criticized for neglecting the role of emotion in thinking (see Thagard, 2012). However, cognitive science actually deals with all mental processes: cognition, motivation, emotion, social interaction, and behavior, which is, in effect, the actuation of the motor system by cognitive processes (Boden, 2006, p. 10). Furthermore, the basic metaphors of cognitive science have been extended to describe the actions of collective groups, as well as the tools and processes which extend behavioral and cognitive processes (Hutchins, 1995).

In this section, I will introduce the history, philosophy and basic metaphors of cognitive science. I will then look more closely at two areas of cognitive science which will be used as important theoretical lenses in this project. One of these is dual-process theory from cognitive psychology. The other is distributed cognition. I will then briefly discuss the existing corpus of work within IS which uses an approach based on cognitive science.

### 2.4.1 Background

The philosophical foundations of cognitive science rest on an analogical association between human information processing and the information processing done by computers (Holyoak, Gentner, & Kokinov, 2001). Just as human thought can be used as a model for the design of machines capable of abstract information processing (see Newell & Simon, 1956), so the operations of the human mind can be modeled as a computational process. At the most abstract level, the “central hypothesis” of cognitive science is that cognition is best understood as an information processing activity which consists of *representations* — mental structures in which information is held — and *transformations* — computational activities which operate on those structures (M. Perry, 2003; Thagard, 2012). The nature of these representations and transformations becomes more contentious as the level of abstraction is

reduced. However, there is broad agreement that representations reflect information structures that represent objects in the external world (Leslie, 1987), and are analogous to computer data structures. Representations are also hypothesized to contain structures such as logical propositions, rules, concepts, images, and analogies. The transformations that those representations undergo are analogous to computational algorithms, and include such procedures as search, matching, retrieval, rotation, and deduction (Thagard, 2012). The computational metaphor has acknowledged limits (Carello, Turvey, Kugler, & Shaw, 1984), but it forms a useful “common language” for the field of cognitive science as a whole, and enables the different research traditions and sub-disciplines to communicate and integrate knowledge.

The discipline of cognitive science arose out of a series of developments in the behavioral sciences that date back to the 1950s. Both Simon (1980) and Newell and Simon (1972) date the changes as beginning around 1956, and state that it was marked by the publication of several seminal papers such as (G. A. Miller, 1956), and (Newell & Simon, 1956). The study of the workings of the mind had been a focus of inquiry by philosophers going back to Plato and Aristotle (Thagard, 2012), but in 1879 Wilhelm Wundt founded the first institute for experimental psychology at Leipzig (A. Kim, 2014), and the study of the mind became more systematic. However, the study of mind soon came to be dominated, along with the discipline of psychology, by a philosophy that was influential during much of the 20<sup>th</sup> century: behaviorism. Behaviorism was a doctrine concerning the appropriate scope of scientific enquiry into human activity that influenced both what kinds of questions were deemed appropriate for scientists, and what kinds of methods could be used to conduct those enquiries. According to Graham (2010), the principal tenets of behaviorism were:

1. Psychology is the science of behavior, and *not* the science of mind
2. Behavior can be fully explained without making reference to mental events or psychological processes. All sources of behavior are external to the individual, and therefore part of the environment; *not* internal, and part of the mind
3. If mental terms or concepts are deployed in theory development in psychology, they should be eliminated and replaced by behavioral terms or translated into behavioral concepts

The correspondence of the tenets of behaviorism with the themes of empiricism and positivism is not a coincidence. The historical roots of behaviorism lie in the influence of the British empiricist philosophers such as Locke and Hume, and the logical positivists (Graham, 2010). Classical associationism, an idea associated with Locke, Hume, and other empiricist philosophers, became the intellectual foundation of several of the most influential programs of research during the early to mid-twentieth century, such as that on classical conditioning (Pavlov, 1927). Classical associationism proposed that mental states followed the assumptions of classical process theories: that is, that each mental state is associated with its successor states. It was also assumed that mental states that resulted in behaviors were the result of

external stimuli, and that internal, unobservable states, were not required in order to explain behavior. That implies that all behavior can be explained by understanding the environmental precursors of those behaviors, rendering non-observable mental states irrelevant to scientific investigation (Skinner, 1953, p. 35). At the same time, any and all research into non-observable mental structures and events was suppressed and marginalized.

The demise of behaviorism as a dominant philosophy in the behavioral sciences began sometime around the mid-1950s. The publications cited by Newell and Simon (1972) were a reflection of a growing perspective among scientists that models were needed to understand how the mind internally represented and processed information, and that the emerging discipline of computer science offered useful metaphors and templates for developing that understanding. The breakdown in confidence among scientists in the behaviorist paradigm led to the rise of a number of critics of behaviorist assumptions in the sciences, some of whom drew a direct line between the increasing rejection of empiricist principles and the untenability of behaviorist assumptions (Nelson, 1969). One of the most effective of these critics was Noam Chomsky (Boden, 2006; Thagard, 2012). Many regard Chomsky's devastating review of (Skinner, 1957) — in which he, in essence, demonstrated that the associationist principles of behaviorism could not account for human language acquisition (Chomsky, 1959) — as being a, if not the, critical event in the demise of behaviorism, and the rise of cognitive science. Behaviorist assumptions did not simply die out as fade away, as the scientific community lost interest in them. Some prominent behaviorists remained committed to their beliefs, but they were increasingly marginalized by the new paradigm (Skinner, 1977, 1987). As behaviorism was rejected, the new perspective, which posited that mental states exist and must be part of scientific inquiry into behavior, came to be known as *cognitivism* (Carruthers, 2009b; Introna & Ilharco, 2004; Lancy, 2010; Leslie, 1987; Searle, 1990).

The successor to behavioral psychology — and one of the most important fields in cognitive science — is cognitive psychology: the sub-discipline of psychology that is devoted to the study of internal mental states. Another foundation of cognitive psychology is conceptual work on the information processing structures of the mind, as in the work of Bechtel (2008), and the work on mental metarepresentational structures by Leslie (1987). Some of the most important work done using the computational metaphor in the early days of the cognitivist paradigm was in the field of visual perception (Marr & Poggio, 1979). Recently, there has been an increasing integration of the work in cognitive psychology and cognitive neuroscience, a development that Thagard (2012) suggests supports the *mind-brain identity theory*. This theory holds that the human “mind” is emergent from entirely physical processes: that is, that states and processes of the mind are identical to states and processes within the brain (Smart, 2012), rejecting the notion that some mental processes have non-physical, psychical elements which are not reducible to physical brain processes. Thagard (2012) also notes that some philosophers object to the mind-brain theory on the grounds that minds are embodied and extend into the world. He argues that the idea of embodied minds is not inconsistent with mind-brain identity because minds have modes of operation that

enable them to interact with the world. This idea will be further explored in the section below on distributed cognition.

Before exploring how the mind interacts with the world, however, I will begin by looking at an emerging literature that explains how the human reasoning system operates that has been gaining influence both in cognitive psychology, and in fields as diverse as economics, marketing, ethics, and geology — dual-process theory.

### **2.4.2 Dual-Process Theory**

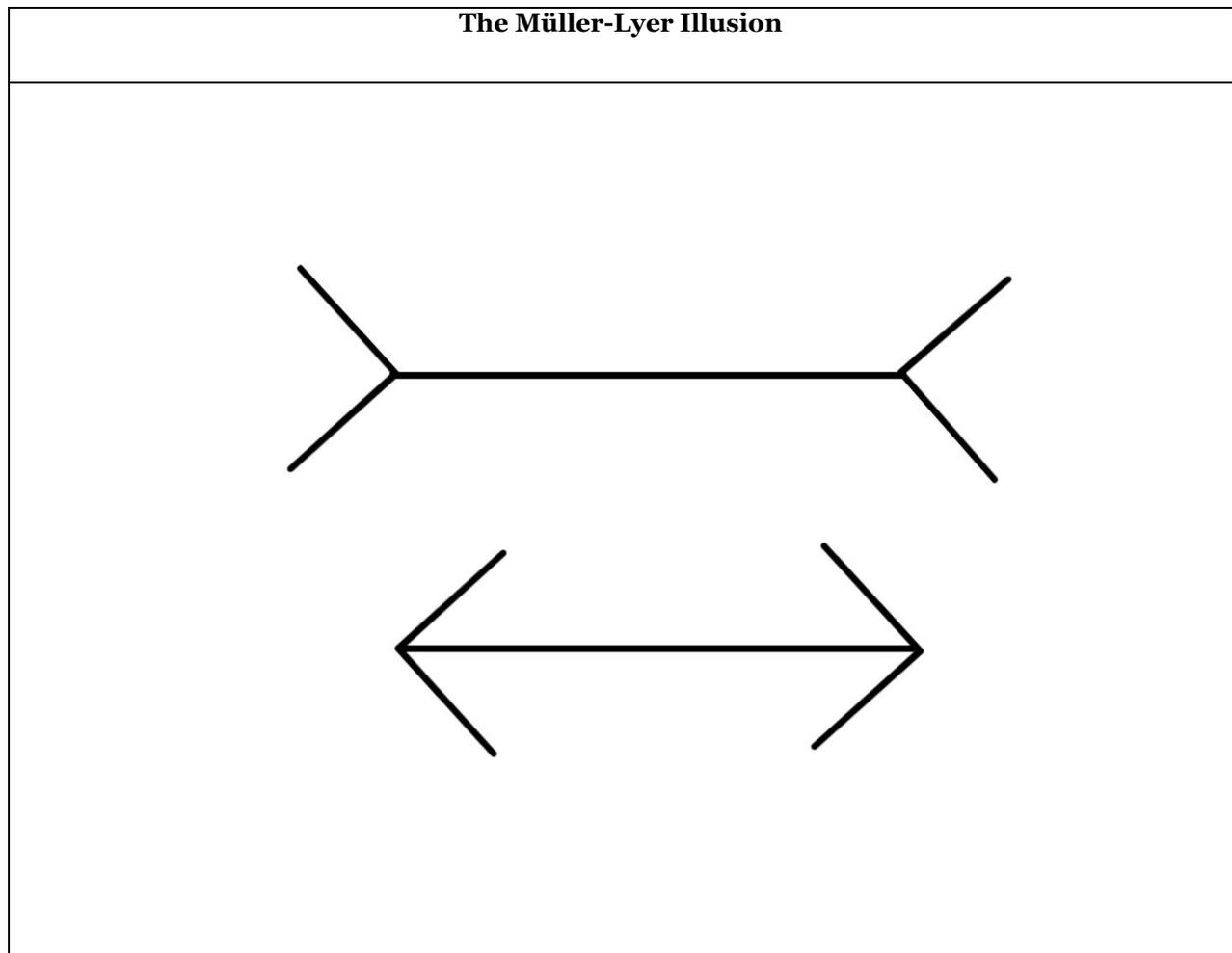
Dual-Process theory is the name that has been given to the study of the structure of the human reasoning system in cognitive psychology (Evans, 2003). The term has previously been used more loosely, for example, in research on stimulus response plasticity (see Groves & Thompson, 1970), but it is now widely accepted as the term describing the sub-field in psychology that looks at the structure of the mind. The label “dual-process” is something of a misnomer: different theories regarding the structure of mind posit different numbers of basic structures (see (Osman, 2004) for an overview), and there are numerous questions about the existence and nature of those structures that are still the subject of ongoing research (Morewedge & Kahneman, 2010). In light of this, the label “dual-process” should be taken more as an indication of what the mind is *not* — a single system — than what it is (Gilbert, 1999).

The notion that the human mind is composed of two parallel but distinct modes of information processing has a long history. The idea of two modes of processing was discussed by Freud (1916, 1953), James (1896), Piaget (1959), and others. More recent work in cognitive psychology has proposed several possible models of the structure of the human reasoning system based on aggregated empirical evidence. Several possible models of the reasoning system have been proposed (Osman, 2004), but the currently dominant view in the literature is a two-system model (Evans, 2008; Stanovich & West, 2000). Current work on the structure of the reasoning system is often cited as having its genesis in (Sloman, 1996), however cognitive scientists — not only in cognitive psychology, but in other sub-fields — have long posited that the mind is composed of two systems with distinct characteristics. Stanovich (2011) lists 30 different terms for the two systems that have been used by different researchers in work going back over 30 years. It has been proposed that these two systems can be distinguished by their computational and activation characteristics, with one acting associatively and reflexively and the other being rule-based, logical hierarchical and causal-mechanical (Sloman, 1996).

The evidence for the existence of two reasoning systems is varied, and some of it is open to multiple interpretations (Evans & Stanovich, 2013; Osman, 2004, p. 1006). However, the conclusion that the mind is composed of many subsystems that those systems form part of a superordinate dual-system model has recurred in conceptualizations in many disciplines (Stanovich, 2011). A comprehensive review of this

evidence is beyond the scope of this section (see (Evans, 2008) for a more thorough review), but I will present some examples to contextualize the following discussion.

The Müller-Lyer illusion (Judd, 1905) is a well-known tool from Gestalt theory. An example of it is presented below:



**Figure 5: The Müller-Lyer Illusion**

Readers familiar with this this illusion will know that the two parallel horizontal lines are exactly the same length. It is possible to test this by measuring the two lines (they are, in fact, exactly the same length). However, when observing the diagram, the knowledge that the two lines are of equal length does not eliminate the perception that they are of different lengths. This implies that *knowing* and *perceiving* are the work of two separate systems, which are capable of generating different responses to the same stimulus under some conditions. Sloman (1996, p. 11) presented this as partial evidence for the existence of two systems, and called conditions under which they generate different stimulus responses *Criterion S* conditions. Further evidence that visual perception involves more than one system can be seen in studies of *subitizing* - the ability to quantify small numbers of objects (typically 3-4) by a *recognition*-based process that is distinct from *counting* (E. L. Kaufman, Lord, Reese, & Volkmann, 1949). For example, Dehaene and Cohen (1994) conducted a study of brain-lesioned patients who were suffering from *simultanagnosia*, a condition which impairs counting ability. They showed evidence not only that different

systems for subtilizing and counting *exist*, but also that they are *separate*: that is, that one can be damaged without impairing the other.

Perhaps the most relevant evidence for dual-process theory that intersects with the study of creativity is the evidence that two processes exist for reasoning. There is extensive evidence that this is the case (Kahneman, 2011; Kahneman & Tversky, 1979; Tversky & Kahneman, 1974). One of the best known is the famous “Linda” problem, posed in a set of experiments in Tversky and Kahneman (1983a). Participants were given the following description:

Linda is 31 years old, single, outspoken and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice, and also participated in anti-nuclear demonstrations. (Tversky & Kahneman, 1983a, p. 297)

Participants were asked to rank eight statements about Linda in order of probability. Two of the statements they were asked to rank were:

- A. Linda is a bank teller
- B. Linda is a bank teller and is active in the feminist movement

It does not take a great deal of statistical training to realize that it is impossible for statement B to have a higher probability than statement A (statement B is a conjunction, and cannot have a higher probability than one of its constituents). However, in experiments, more than 80% of the time statement B was ranked higher than statement A. Of course, the profile of Linda is written to resemble that of someone who would be active in the feminist movement. Tversky and Kahneman (1983a) used “Linda” – and other similarly-constructed fictitious profiles – to test the judgment of both statistically sophisticated and unsophisticated participants. They found that both sophisticated and unsophisticated participants tended to make the conjunction error. Further, they found that sophisticated participants were just as likely to make the error as unsophisticated. Medical students also made conjunction errors when presented with artificial medical problems that matched the structure of the Linda problem. This strongly suggests that there is a separate system for making decisions that does not rely on logical inference, but on recognition of similarity to preexisting schemas. It also implies that even highly intelligent individuals can make decisions based on this system, even when it leads to illogical results. This finding is consistent with other research that has found that cognitive biases are not attenuated by cognitive sophistication (West, Meserve, & Stanovich, 2012). There seem to be different systems for *knowing* and *intuiting*, and the intuiting system appears able to drive decision-making even in circumstances where it conflicts with the knowing system.

Stanovich and West (2000) proposed a label for the two processing modes: System 1 and System 2. System 1 is a non-conscious automatic system, while System 2 is a conscious volitional system. System 1 is

primarily characterized by its *automaticity*: it is reflexively triggered whenever salient stimuli are encountered and it cannot be turned off. System 2 is rule-based, conscious, and under volitional control. System 2 is primarily characterized by a tendency for effort minimization, or *laziness* (Kahneman, 2011). The two systems overlap to some extent in terms of the range of stimuli to which they can each generate a response, however the activational characteristics of the two systems influence which response prevails: i.e., which one results in observable behavior. If a stimulus is encountered that triggers System 1, its response must be actively suppressed if a response generated by System 2 is to prevail over that response. In the following sections I will introduce the main features of System 1 and System 2 in basic detail. I acknowledge here that there are different views on the precise structure of the reasoning system (see (Osman, 2004) and (Morewedge & Kahneman, 2010)). In this section I will attempt to provide information based on the most widely accepted current conceptualizations.

#### **2.4.2.1 System 1 Characteristics**

System 1 is an automatic, autonomous, non-conscious system that forms part of the reasoning mechanism in the mind. It is not available to conscious awareness and is not under volitional control. System 1 is autonomous: it generates a response to any stimulus that it can be triggered by every time that stimulus is presented, and cannot be turned off. System 1 processes execute rapidly, with little effort, and do not require access to working memory. They are highly modular and can execute in parallel without interfering with each other, or with System 2 processes; this gives System 1 a high capacity for stimulus response. It is fundamentally associative in nature and can be trained by experiences, such as statistical and temporal regularities and patterns in the environment. The performance of System 1 processes exhibit very little variability across individuals (Evans & Stanovich, 2013; Kahneman, 2011; Morewedge & Kahneman, 2010; Sloman, 1996; Stanovich, 2011).

System 1 processes are responsible for a number of basic brain functions, including the preprocessing of sensory stimuli, physical coordination, and memory operations such as encoding and fetching data to and from long term memory. System 1 processes are capable of learning and taking over the performance of quite complex physical and mental operations that are originally implemented by System 2, when those operations are implicitly encoded into System 1 through repetition. Such tasks become part of the Tightly Compiled Learned Information (TCLI) knowledge base of System 1; which is distinct from the Encoded Knowledge Base (ENB) which is “built in” to the system (Stanovich, 2011). It is also responsible for some routine elements of cognitive activity such as the direction of attention and determining the salience of different stimuli in complex environments. System 1 processes also include emotional reactions and value judgments. It is capable of performing simple mathematical computations (such as visual quantity comparison and subitizing) but is generally not capable of multivariate calculation or complex explicit information processing.

System 1 is generally thought to be composed of elements of the cognitive system that are evolutionarily old and shared with other animals. It is non-heritable and independent of general intelligence, and tends to perform at the same level across individuals. In debates on rationality, it has been hypothesized that System 1 processes tend to optimize for evolutionary fitness (Stanovich, 2011).

#### **2.4.2.2 System 2 Characteristics**

System 2 is a conscious, reflective system that forms part of the reasoning mechanism of the mind. System 2 is self-aware and capable of metacognition; it is the part of the mind that persons are referring to when they use the referential term “I”. It is capable of opting to respond – or not to respond – to a stimulus. System 2 processes are relatively slow (compared to System 1 processes) and computationally expensive. Measurable physiological arousal accompanies the activation of System 2 processes. They tend to execute serially, and interfere with each other – that is, performance on any System 2 task falls rapidly if it is forced to be performed in parallel with another System 2 task. The capacity of System 2 processes are limited by working memory capacity and the efficiency of the system can be affected by the use of strategies to complete cognitive tasks. System 2 spends much of its time in a low-power state of activation that taps only a fraction of its capacity, and forcing it to perform tasks which engage its full capacity is highly aversive and leads to rapid fatigue (Evans & Stanovich, 2013; Kahneman, 2011; Morewedge & Kahneman, 2010; Sloman, 1996; Stanovich, 2011).

System 2 is fundamentally rule-based in its operations (Anderson, 1993; Satzinger et al., 1999, p. 148), and it is capable of learning through explicit training and information processing. One of the most important functions of System 2 is to inhibit System 1; that is, to suppress System 1 responses to stimuli in conditions when the implicit responses of System 1 are less than optimal strategies for responding to a stimulus. When this is done, System 2 must both suppress the System 1 response and generate a response to the stimulus. This process is computationally expensive and aversive for System 2. System 2 processes are necessary for complex mental operations such as multivariate calculation, abstract thought, and fully understanding language. System 1 processes are capable of responding to such stimuli, but lack the capacity for complex information processing that are part of System 2.

System 2 is generally thought to be composed of elements of the cognitive system that are evolutionarily recent and uniquely human. They are heritable, and their performance varies significantly between individuals. The individual differences in System 2 performance are related to scores on tests of intelligence, but the meaning of intelligence test scores remains an area of active debate (Stanovich, 2009). In debates on rationality, it has been hypothesized that System 2 processes tend to optimize for individual goal-seeking (Stanovich, 2011).

### **2.4.2.3 The Two Systems**

According to Sloman (2002), the relationship between the two systems of reasoning is interactive and complementary. The degree to which each is active in any given problem situation may vary with the individual, dependent on variables such as skill, knowledge, intelligence and experience. Neither system has any exclusive problem domain (though it must be noted that this is only true for the reasoning functions of System 1 and System 2. Some physical functions, such as visual perception, appear to have dedicated automatic processes assigned to certain tasks (Treisman & Gelade, 1980)).

One implication of the two systems can be realized by contemplating the essential nature of each. System 1 is above all *automatic*: generating a response to every stimulus it is presented with that it is capable of responding to. System 2 is above all an *effort minimizer*. It avoids responding to any stimulus that it can. It stands to reason that the emergent behavior of the two systems will be highly driven by System 1. However the conscious mind, the “I”, unable to perceive System 1, confabulates explanations for behavior that omit the role of System 1 (Carruthers, 2009a). The implications of this are profound: most definitions of “consciousness” attribute qualities such as awareness and volitional control to that state. If most human behavior is largely controlled by a non-conscious, automatic system of reasoning, of which we cannot be aware, then to what extent can humans truly be said to be conscious beings (Evans, 2009)?

### **2.4.2.4 Discussion**

The concept of System 1 and System 2 have been described as useful for introducing the two-systems hypothesis of brain function (commonly dual-process theory (Osman, 2004)) to non-specialist audiences (Kahneman, 2011; V. A. Thompson, 2009). However, the reification of System 1 and System 2 has been criticized by some cognitive scientists. Describing two reasoning systems has been incorrectly construed to imply that they map to two different biological systems within the brain, something that dual-process theory does not actually support. Also, the conceptualization of two separate systems tends to obscure one of the defining characteristics of System 1: its modularity and capacity for parallel processing. There is increasing evidence that System 1 and System 2 may consist, not only of different processes, but of different types of processes, so that conceptualizing them as “two systems” may raise issues of construct validity when interpreting experimental data.

Altogether the current model of dual-process theory — like the most current work in many fields — should be seen as a work-in-progress rather than a definitive view of the structure of the reasoning system. The most respected writers on dual-process theory are unanimous in asserting that further work will enhance our understanding of a number of issues in regard to understanding how the mind processes information (Evans, 2008; Morewedge & Kahneman, 2010; Stanovich, 2011). Indeed, the current consensus among some of the leading authors in the field seems to be trending toward a three-process model: one that acknowledges the multiplicity of types of processes that constitute System 1, but collates them on the basis

of automaticity and lack of volitional control (Evans, 2008); and bifurcates System 2 into a computational engine and an executive function (Stanovich, 2009; Stanovich, 2011; Toplak, West, & Stanovich, 2013).

For these and other reasons, Stanovich - who created the nomenclature of System 1 and 2 (Stanovich, 1999), no longer uses the terms. He has adopted the terminology of Type 1 and Type 2 processes (Stanovich, 2011). However the terms System 1 and System 2 have come to be widely accepted and commonly used in the literature (Evans, 2008; V. A. Thompson, 2009), and can be viewed as structural mechanisms which are emergent from lower-level processes (Hedström & Ylikoski, 2010). Therefore, in this thesis, the concepts of System 1 and System 2 will be used for the two primary reasoning systems in the mind.

### **2.4.3 Distributed Cognition**

The fundamental assumption of cognitive science is that human cognition is, essentially, a computational activity. The basic metaphors used to describe this activity is that of cognitive representations, mental models of things in the external world; and transformations, computational processes which manipulate representations. Hutchins (1995) demonstrated that these computational processes are not necessarily contained within the minds of single individuals. He showed – in an ethnographic investigation of the process of navigation aboard a U.S. Navy ship – that the computationally intensive process of navigating the ship was broken into a variety of computationally non-intensive sub-tasks that were distributed across a range of individuals, objects (tools), and coordinating procedures. This meant that while the overall task of ‘navigation’ was being done, there was no single individual or tool which could be accurately said to be ‘navigating’. Although no single individual or tool was ‘doing’ the navigation task in its entirety, the task was being done by the entire system through the coordinated activity of each node. Hutchins’ landmark study is commonly recognized as marking the beginning of the field of *Distributed Cognition* (DC).

DC draws its theoretical and analytical foundations from cognitive science (M. J. Perry & Macredie, 2005). It proposes that distributed cognitive systems form representations of the world, in much the same way that individual minds do. It focuses on the media which encode those representations, the transformation of those representations, and the actors who coordinate those transformations. The major difference between DC and many other disciplines within cognitive science is that it holds, and focuses attention on, the fact that representations may be held in both neuronal and non-neuronal media (e.g., paper, spreadsheets, physical models, etc.) and may be shared across individuals. The fact that representations may be shared and transformed across a number of individuals working in coordination makes DC a powerful tool for analyzing collective activities. It does so by focusing on the information content of events in the world, and abstracting those events into information-processing events (M. J. Perry & Macredie, 2005, p. 1).

Much of the work in DC has focused on relatively structured tasks within well-ordered groups. For example, DC has been used as a lens to understand collaboration in software development teams (Flor & Hutchins, 1992), and in airliner cockpits (Hutchins & Klausen, 1996). However DC has also been proposed as a tool for understanding work in organizations (Perry 2003; Perry and Macredie 2005). In addition, Thagard (2010) has looked at the fact that distinguished commentators have attributed the behavior of collective organizations such as banks and governments to human qualities such as beliefs, desires and emotions. He concludes that such attributions of cognitions to collective groups in economics constitute metaphorical pointers to a set of underlying psychological and social mechanisms which explain emergent collective behaviors; mechanisms which work at multiple levels (Thagard, 2010, pp. 271-273). While he rejects the notion that banks and governments have actual mental representations such as exist in human minds (because human representations in minds require the neuronal architecture of brains to exist); he holds that such metaphors are useful pointers to the underlying complex mechanisms.

In similar fashion, the fact that DC extends metaphors from cognitive science to real-world teams – and even organizations – does not mean that it proposes that groups and organizations are analogues to the human mind. DC systems have different architectures from mental systems, and will behave differently. However, individual and collective cognitive systems have to perform the same basic tasks: processing information, and solving problems (Perry and Macredie 2005); in performing those tasks, both individuals and collectives have to compete, collaborate, make decisions and evaluate outcomes. It makes sense that, at an appropriate level of abstraction, some underlying mechanisms which operate in one type of system may operate in the other. This notion is not uncommon in the philosophy of science. Walsham (1995b), citing Archer (1988), speaks of the philosophical position of “internal realism”, which holds that individual perceptions of reality are an intersubjective product of the “shared human cognitive apparatus” (Walsham, 1995b, p. 75). The idea that the “mind” extends beyond the brain into the physical world has also been explored by (Clark, 2008; Clark & Chalmers, 1998; Dror & Harnad, 2008).

Distributed cognition will therefore be utilized as a lens for this thesis.

#### **2.4.4 Cognitive Research in IS**

An assessment of the state of cognitive research in IS is made simpler by a recent series of articles in the *Journal of the Association of Information Systems*. Davern, Shaft, and Te'eni (2012a) conducted a topical review of the history cognitive research in IS. They focused on three areas: software development, decision support, and human computer interaction. Browne and Parsons (2012) published a critique of their article, proposing further streams of cognitive research in IS that they felt were insufficiently covered by (Davern et al., 2012a), with a focus on systems analysis and design. Davern, Shaft, and Te'eni (2012b) then replied to Browne and Parsons (2012). The resulting exchange provides a broad, though not completely comprehensive (Davern et al., 2012b, p. 1013) overview of the history and current state of

cognitive research in the IS discipline. While a restatement of the substance of the articles would be redundant, a few general comments can be made.

Cognitive research is an established theoretical perspective within the IS discipline. The history of cognitive research in different domains of IS goes back to the 1970s, investigating a slate of topics that have evolved over time. Early studies made limited use of psychological theories, which were in an early stage of development at the time, but theories of cognition have been increasingly integrated into IS research as theory development in broader cognitive science has advanced. One theme that emerges from Davern et al. (2012a) is the critical role of theory development in the advancement of work in each research stream that they reviewed. For each stream they note how critical the development of theoretical frameworks were to the advancement of work in IS within the field. They also find the concept of Affordances, from the work of Gibson (1979) to be one of the fundamental concepts necessary to examine how users interact with IT.

For the future, Davern et al. (2012a) note that future research in IS will require a shift away from exclusively experimental methods of exploring cognition; to the incorporation of field work, such as the cognitive anthropological work of Hutchins and Lintern (1995). They see distributed cognition as the foundation for cognitive IS research that can investigate rich, contextual environments and develop useful real-world theories (Davern et al., 2012a, p. 302). However, a critical theoretical lacuna emerges over the course of the (Browne & Parsons, 2012; Davern et al., 2012a, 2012b) discourse: a surprising lack of mention of dual process theories of cognition. While both Davern et al. (2012a) and Browne and Parsons (2012) look at areas which have been explained in terms of dual process theories, it does not appear that dual process perspectives have become a significant part of the discourse in what Davern et al. (2012a) call Cognitive IS. Indeed, while Davern et al. (2012a) state their goal as primarily one of historical review, Browne and Parsons (2012) delve deeply into the heuristics and biases literature, raising issues that have been a focus of explanatory models based on dual-process theories (Kahneman, 2011). In fact, though dual-process theories of cognition have seldom been mentioned in the IS literature (see Avgerou, 2013; Zhang, 2013), a number of emerging topics in the literature would benefit greatly from the application of existing dual-process perspectives (Guinea & Markus, 2009; S. S. Kim, Malhotra, & Narasimhan, 2005; Polites & Karahanna, 2013; E. V. Wilson et al., 2010). Dual-process accounts of the structure of the reasoning system have been brought into a number of behavioral fields with promising results (see Haidt, 2001, 2007), and promises to contribute greatly to an understanding of how people relate to information systems.

In this thesis, I will address a number of the issues that can be gleaned from a review of the prior research in cognition in IS. I will apply and extend existing theory, both from the reference disciplines and from IS. As recommended by Davern et al. (2012a, p. 302), this thesis will incorporate field investigations of rich real-world contexts using distributed cognition as a lens. In so doing, I will draw on the work of Gibson

(1979) and propose another method for applying the affordance concept and insights from cognitive science in an IS investigation of how users use IT. Perhaps most significantly, however, I will demonstrate how dual-process theory can be harnessed to make sense of user interactions with IT systems and explain real-world behaviors.

### 2.4.5 Discussion

Despite its wide influence, the computer metaphor for the working of the mind has not been universally accepted. A number of challenges have been raised showing that the phenomenon of “mind” cannot be fully explained using the design principles of physical machines (Penrose, 1999), and challenging the fundamental concept of mind-as-computer. However, many of those challenges are, in fact, challenges to “Strong AI”. Strong AI, at its simplest, can be viewed as the assumption that there is some algorithm — not currently known — which, if implemented on a universal Turing machine, would result in intelligence and consciousness. An assumption that is often linked with Strong AI is that the brain is a universal Turing machine, and the mind is an algorithm that runs on the brain (see Searle, 1990). Strong AI is “strong” in contrast to “Weak AI”, which simply holds that some operations of the mind can be represented algorithmically. Although many critics of cognitivism have based their criticism on undermining the foundations of Strong AI, few, if any, working cognitive scientists actually hold this view. Strong AI can be regarded as a useful thought experiment for asking certain questions about the nature of mind, but in practice it seems to serve more often as a straw man for critics of cognitive science (see Searle, 1990).

While there may be problems mapping conceptual mental representations to physical events and processes within the neuronal structures of the brain, *representations themselves are abstract*. For example, the number *two* can be represented in many ways, including

Arabic base 10	2
Binary	10
Roman	II
A rule	1+1
Another rule	3-1

Each of the above are representations of the exact same thing — the number two. The specific mechanics of how it is represented do not change its essential nature. In order to make use of the mind-computer analogy it is not necessary to believe that the mind operates exactly like a computer, or that a suitably-written computer program can duplicate a mind.

Marr (1982) proposed a series of levels at which one can describe a complex information-processing system. They are:

- **Computational Theory** – The most abstract level. Describe what the system does, and the logic of the strategy it uses to do them
- **Representation and Algorithm** – Describe the representation for the inputs and outputs to the system. Describe the algorithm that is used to transform input to output
- **Hardware Implementation** – Describe how the system is physically implemented. Describe how the representation and algorithm are implemented on a physical level (whether biological or mechanical)

Marr was addressing a specific problem in visual perception: attempts to understand how “seeing” worked in humans, and could be simulated by machines, were hampered by the lack of an understanding of the top-level workings of the visual system: the computational theory level. Without a theoretical understanding of the process of seeing and perceiving, the substantial (then-) existing corpus of research on the basic mechanics of perception did not add up to a useful explanation of the phenomenon. Marr points out that understanding the computational theory level of the system is a critical first step to understanding, since without a solid understanding at that level, one is unlikely to be able to get useful information from observations at the second and third levels (Marr, 1982, p. 27).

Marr (1982)’s principle can be abstracted to the study of creativity. There is a great deal of existing research on creativity which looks at aspects of the phenomenon, but, with some significant exceptions (Amabile, 1996; Dunbar, 1997; R.K. Sawyer, 2012), much of the creativity research has focused on a single level, making it difficult to apply findings from such research at other levels. That is, it is difficult to apply findings from brain-imaging studies (Abraham, 2007; Abraham & Windmann, 2008) and lab experiments (Silvia, Winterstein, Willse, Barona, & Cram, 2008; T. B. Ward et al., 1999) in field settings, for example, without an overarching theory at what Marr (1982) described as the computational theory level. The strategy of using conceptual levels of organization to integrate knowledge at different levels has been widely used in cognitive science (Bechtel, 2008), and provides useful clues about how this problem may be approached in studying creative appropriation.

## **2.5 Discussion**

There have been a number of engagements in IS research with topics which are conceptually similar to creative appropriation. These include Reinvention (B. Johnson & Rice, 1984; Nevo & Nevo, 2011; Rice & Rogers, 1980), Innovation (Aaen, 2008; R. Agarwal & Prasad, 1998; Tuomi, 2002), and Adaptation (Beaudry & Pinsonneault, 2005; Elie-Dit-Cosaque & Straub, 2010; Heshan Sun, 2012). Stage theories of IT implementation and use have posited stages of exploratory use patterns which result in the discovery of novel ways of using systems (Jasperson et al., 2005). In a sense, it can be said that all of these phenomena

have user creativity at their core: they all study phenomena that emerge when users implement novel and useful ways of using systems. As such, it can be said that user creativity is a common thread running through several research domains in IS. There can be some overlap in the definitions of these phenomena and some definitions of creativity. For example, when using a product definition of creativity (Rhodes, 1961), there is considerable overlap with many definitions of innovation – a process that results in the creation of a novel and useful product. However, innovation research tends to focus on the output of the process, though the output must be preceded by ideation. Creativity research tends to focus on the generation of creative ideas that are inputs to the process, though the “creativity” of the ideas is validated by the qualities of the output. Creativity research has its own body of literature, and its own research traditions. However, that body of knowledge is seldom applied in IS, although the basic phenomenon that it describes – the generation and implementation of creative ideas – is highly relevant to number of active research domains in the field. It is now possible to propose a possible explanation for this anomaly.

The discipline of information systems emerged from the behavioral and computer sciences sometime between the late 1950s and early 1960s. It apparently emerged just in time to miss the major debates that were beginning to reshape the sciences in general, and the behavioral sciences in particular. For decades the behavioral sciences had been dominated by the Behaviorist paradigm, and from that paradigm IS inherited a number of assumptions about the “human” and “social” side of an information system: associationist, determinist, empiricist assumptions that shaped its approach to studying behavior. This continued to shape the way IS conducted research for two decades.

In the 1980s, IS underwent a transformation in its metatheoretical assumptions. It came to accept interpretivist ideas about the subjective nature of knowledge, the stochastic nature of measurement and the fact that the world was complex in ways that classical positivist models could not explain. It accepted ideas about interpretivism, and its major journals published guidance on how to conduct interpretive research. Then something strange happened: very little. Yes, there was some interpretive work done, but overall, reviews of the literature have found that “positivist” research, particularly survey-based quantitative work, continued to dominate the research output of the field, and the proportions of interpretive work, as well as intensive idiographic work as a whole, did grow, but not as much as it might have been expected. A number of possible reasons for this have been proposed, including the structural advantages of positivist research for early-career academics (W. Chen & Hirschheim, 2004; Walsham, 1995a). These factors did explain some of what was going on, but there was something else as well.

In the late 1980s, just as the shift in metatheoretical assumptions was taking place in IS, the most successful positivist model that the field had ever produced emerged. The Technology Acceptance Model – parsimonious, reliable, and widely-accepted – became a shot in the arm for researchers in IS who practiced questionnaire-based survey research. The result was a strange deadlock. The IS discipline became open and multi-metatheoretical in principle, but its research camps remained highly segregated

in practice, and its methods were much less transformed by the change than one might expect. In particular, the ways in which the use of IT was conceptualized and measured in IS research remained largely unchanged. This lasted another two decades. The IS discipline now seems to be in the midst of a new transformation, one in which these representational strategies are being challenged, and potential new strategies are being proposed. Much like the transformation in metatheory, it seems likely that this will result, not in a single dominant model, but in a kind of pluralism.

And what of creativity? Feldman and Pentland (2003) adapted Latour (1986)'s concept of there being *ostensive* and *performative* dimensions to routines, showing that routines have both recognizable general and particular individual aspects. Creativity is very similar, in that it has an ostensive dimension (a creative incident is recognizable as “creative”), but also a performative dimension (each creative act is novel). This is exactly the kind of phenomenon that one would expect to be understudied under a condition where there are general constructs to iterate repetitive actions (as in the automation of clerical tasks) and specific representations of idiographic phenomena, but little way of representing phenomena with both an ostensive and a performative aspect. I propose that this, as much as any other factor, explains the remarkable lack of creativity research in IS over the past 40 years.

The lag in creativity research in IS would therefore be related to the fact that IS did not take part in the cognitivist revolution in the behavioral sciences that occurred in the mid-1950s to early 1960s, as indicated by the surge of important papers in that tradition during that period (G. A. Miller, 1956; Newell & Simon, 1956; Simon, 1956). The view that the empiricist and associationist assumptions of behaviorism inhibit the study of creativity is supported by the fact that the formal study of creativity took off during the decade of the sixties – just as cognitivism was supplanting behaviorism (Google, 2014). One of the results of that revolution was the emergence of the discipline of cognitive science, and with it, the sub-discipline of cognitive psychology. It is possible that IS should look to cognitive science, which, after all, was born out of the same challenge that IS faces many years after it began: to adjust its perspectives and conceptualizations to meet the challenges of a move away from purely positivist assumptions. For example, dual-process theory has been used in other fields to look at creativity, for example, by Dreyfus (2009).

In this thesis, I will utilize the basic assumptions of cognitive science and lenses drawn from cognitive psychology. I will use them to develop a theoretical model of the mechanisms involved in the creative appropriation of IT by users. In doing so, I will apply neither positivist nor interpretive assumptions, but rather, critical realist. I will introduce critical realism in the following chapter.

## **Chapter 3. Theoretical Framing**

### **3.1 Philosophy and Methods**

In the previous chapter I introduced the debate between positivism and interpretivism that has had a significant impact on the way that theorizing is done in IS over the past several decades. I also showed how this debate has been a reflection of wider philosophical debates in both IS reference disciplines and the philosophy of science as a whole. However, the wider debates have not been limited to the positivist/interpretivist positions. Around the late 1950s to the 1960s, at about the same time that cognitivism was supplanting behaviorism as the dominant paradigm in the behavioral sciences, a number of philosophers were offering new metatheoretical frameworks. These included Bunge, Giddens, Bhaskar, and Harre (Bhaskar's dissertation advisor). While their philosophies were distinct, several of them shared a number of features, such as the notion of structure (though, as I will discuss, the meaning of the concept varied), a stratified model of reality, and the notion of explanation via mechanism.

One of these philosophers — Anthony Giddens — has had a substantial impact on theorizing in IS (Giddens, 1984). This began largely through the work of DeSanctis and Poole (1994), but has expanded to a significant body of work based on Giddens' structuration theory (see (Jones & Karsten, 2008; Poole & DeSanctis, 2004)), on which I will comment further in a later section. However, in this thesis, I will be applying another metatheoretical model which has been gaining a great deal of attention in IS research: the Critical Realist model, proposed by Bhaskar (1975). In this chapter, I will briefly discuss the philosophical issues that have led to this choice of metatheoretical framing. I will then introduce critical realism and outline the assumptions and methodological principles that will be followed in this study. I will then briefly review some existing critical realist research in IS, and discuss how the critical realist model may influence future work in the discipline.

### **3.2 Causality and Explanation**

The goal of this thesis is to explain user creativity. Arguments about explanation often actually arguments about causality: that is, to explain something is often equivalent to describing its cause (Gregor, 2006, p. 617). Both explanation and causality are deceptively simple concepts, which require careful examination and definition in a study which seeks to develop a theoretical explanation of a real-world phenomenon. Critical realist researchers frequently claim that the approach they advocate generates stronger explanations for observed phenomena than other approaches (Mingers, 2004c; Wynn & Williams, 2012). Before evaluating this claim, some basic questions need to be considered.

The first, and perhaps most fundamental, of these is how I will describe cause. Assume that a *change of state* (Markus & Robey, 1988, p. 590) occurs in the world. We will call this state change an *event*, and assign it the label *B*. *B* is observed to occur, and it is suspected that another event *A* caused *B*, how should the relationship between *A* and *B* be conceptualized, expressed and tested?

Outside of purely symbolic domains such as mathematics, causal statements can typically not be proved in an absolute sense, and so must be proposed as conjectural statements and supported from evidence until they inspire a degree of confidence. That means that causal explanations are *theories*. There are generally accepted to be two forms of theory: variance theory and process theory (Mohr, 1982). Variance theory reflects Humean assumptions about causal relations (Mingers, 2003a). In a variance theory in which *A* causes *B*, there would be a system of variables which represent *A* and *B*. A statement (or theory) explaining how *A* causes *B* would state the values of the variables representing *A* that will force *B* to occur. These values of *A* will, *ceteris paribus*, always cause *B*, and a variance theory is not required to state a mechanism by which *A* exercises this power on *B*, and *A* is assumed to be both a necessary and sufficient condition for the occurrence of *B* (Abbott, 1990, 1992; Markus & Robey, 1988).

In a process theory in which *A* causes *B*, a temporally ordered series of necessary events by which the direct consequences of *A* lead through a sequence of actions to *B* is described. The sequence of events contains necessary conditions for *A* to lead to *B*: if the causal chain includes event *X*, then *A* will not lead to *B* if *X* is not present. However the role of random occurrences in events means that the necessary conditions do not guarantee that event *A* will invariably lead to event *B*. The process theory therefore states what is necessary, but not sufficient, to explain *B*. Critically, a process theory will not only state *that* *A* causes *B*, but will also indicate *how* *A* leads to *B*, and *why* (Markus & Robey, 1988).

Because of the requirement to observe intervening states, rather than simply conjunctions between antecedents and outcomes, process theories are more resource-intensive to create than variance theories (Abbott, 1992). Also, the assumptions of variance theory allow researchers to use powerful mathematical techniques to discover relationships between antecedent and consequent variables (Abbott, 1990, p. 376). This is reflected in the fact that studies employing variance approaches have consistently outnumbered process-type studies (Orlikowski & Baroudi, 1991), though recent reviews show the number of process-type studies increasing (W. Chen & Hirschheim, 2004).

Another kind of theoretical explanation which has been used extensively in the physical and biological sciences, and which is now gaining popularity in the social sciences, is explanation via mechanism (Bechtel, 2005; Bechtel & Abrahamsen, 2005; Hedström & Ylikoski, 2010). A mechanism-based explanation of how *A* causes *B* will show a series steps by which the direct consequences of *A* lead to *B* through the actions of intervening structures. These are the kinds of explanations that critical realist theories develop. Critical realist (hereafter, CR) explanations are based around the description of mechanisms: explanations that “detail the cogs and wheels of the causal process through which the

outcome to be explained was brought about” (Hedström & Ylikoski, 2010, p. 50). Mechanism-based theories based on critical realist assumptions have been described as a kind of explanatory process theory (Volkoff, Strong, & Elmes, 2007, p. 835), however, this is somewhat misleading. CR theories do not necessarily make the claim to necessary temporal ordering of event chains that is integral to classical process theory. The focus is not on identifying the sequence of events that is critical to an outcome, but rather identifying the mechanisms that are causally relevant to the outcome; and showing how the antecedent conditions to the event enabled those mechanisms to have the observed effect. Avgerou (2013) has noted that mechanisms can be seen as processes in their own right, which can concatenate into larger process theories. However CR explanations are based on a set of ontological assumptions and epistemological principles that make them distinct from both variance and narrative positivist explanations (Abbott, 1992).

### 3.3 Critical Realism

Critical realism (CR) was popularized by Bhaskar (1975). It posits that there is a difference between the ontological world (external reality, which exists independent of the individual) and the epistemological world (human knowledge structures which represent the ontological world within the human mind). More specifically, it takes a position which is:

- *Ontologically realist*: It assumes that external reality exists independent of its social construction. There are natural structures, mechanisms and actualities which have properties that are, and are not socially constructed or subjective in nature.
- *Epistemologically relativist*: It assumes that our knowledge of the ontological world is limited, subjective and socially constructed. This means that the representations of reality within the mind are inherently partial and imperfect, but that these partial and imperfect understandings do approximate, with varying degrees of specificity and faithfulness, some actual external phenomenon.

In taking this view of the world and its representation in the mind, critical realism attempts to avoid the epistemic fallacy – in which statements about being are interpreted as statements about knowledge, and the ontic fallacy – in which the cognitive and social processes involved in knowledge creation are ignored, leading to the interpretation of knowledge structures as unfiltered objective reality (Irwin, 1997). H. K. Klein (2004), citing (Mingers, 2001), has labeled CR “a type of ontology with secondary epistemological consequences.” Klein’s description was meant as part of a critique of the CR position, but it provides an effective way of thinking about how CR is different from the more commonly-applied metatheoretical positions of positivism and interpretivism. Critical realism emerged from critiques of both those philosophies (see Danermark et al., 2002), and its development is commonly attributed to the work of (Bhaskar, 1975, 2008). However, a number of philosophers have contributed to critical realism (see

(Danermark et al., 2002; Dobson, 2001; Dobson, Myles, & Jackson, 2007; Irwin, 1997; Mingers, 2004b, 2004c; Mingers, Mutch, & Willcocks, 2011; Sayer, 1992, 2000)), and it continues to be developed today (K. D. Miller & Tsang, 2011). The key assumption of CR is that reality is stratified, and that observations, transient events, and underlying structures, exist at different strata of reality.

Walsham (1995a, p. 381) notes that when metatheoretical positions become well established – to the point of being “tacit knowledge” in a field – they no longer have to be discussed or defended by researchers applying them. For example, positivist researchers conducting surveys do not have to defend the acceptability of survey methodology. CR has not yet reached that point, despite strong signs of acceptance within the field. I will therefore discuss CR, and defend the decision to use it as the underlying philosophical position of this project. I will begin by looking at the basic ontological and epistemological assumptions on which critical realism is based. I will then look at how these assumptions shape the methodological principles followed in critical realist research. In this effort, I will be guided by the methodological principles laid out by Wynn and Williams (2012), who synthesized a number of methodological models into a set of recommended principles for researchers applying critical realism in IS case studies. I will then look at critical realist research specifically from an IS context.

### 3.3.1 Fundamental Assumptions

The ontological assumptions of critical realism are summarized by Wynn and Williams (2012) as follows:

- *Independent Reality* – The entities which make up the world have existence which is independent of human perceptions of those entities. Specifically, the entities in the world exist in an intransitive domain, and human perceptions of those entities – while having real existence – occupy a parallel transitive domain and cannot be equated to the intransitive entities which they represent
- *Stratified Ontology* – Reality is stratified into the nested domains of the Real, Actual and Empirical. This contrasts with the ‘flat’ ontologies which conceive of the world as a set of conjunctions of cause and effect; as well as some of the constructivist ontologies which conceive of the world as a social construction.
- *Emergence* – The properties of entities that exist in reality are independent from, and cannot be reduced to, the properties of their component parts (Easton, 2010). This means, for example, that the properties of groups cannot be understood simply by understanding the properties of members of those groups. Entities have their own existence and properties. It also means that phenomena which occur at a certain level must be analyzed at that level. For example, memory emerges from the biological level, but it has emergent properties as a thing unto itself that cannot be explained solely at that level (Mutch, 2010, p. 509).

- *Open Systems Perspective* – Reality is an open system which cannot be controlled directly by humans. This means that the outcomes of the operation of the various causal mechanisms within the domain of the Real can never be fully predicted, since other mechanisms which also have causal effects may also affect those outcomes. In some circumstances, such as in experiments in the natural and physical sciences, systems may be artificially ‘closed’ in order to observe predicted effects. However, in social systems, such closure is unlikely to ever occur (Tsoukas, 1989). This implies that the critical realist, instead of trying to make predictions of outcomes based on causal factors, will rather focus on explaining observed outcomes through description of the causal mechanisms which generated them.

### 3.3.2 Ontology

Critical realism takes an ontologically realist position that accepts the existence of an intransitive reality that is independent of human observers. It thus rejects the position of some of the stronger forms of interpretivism that objective reality does not exist and that the world is a social construction of human actors (Rorty & Williams, 1980). However, it at the same time takes an epistemologically relativist position: it rejects the view that objective reality can be fully and unproblematically measured - and thus understood - by humans. For critical realists, human knowledge is fallible and transitive. The key to understanding these two positions is one of the foundations of critical realism: a stratified ontology.

In the critical realist model, reality is divided into three levels, or domains. There is a domain of events which are experienced by human observers. However, observation can often prove problematic. Observation itself can involve learned skills, and preparation – for example, scientific training – which is not available to all observers (Mingers, 2004b, p. 381). Special equipment is sometimes necessary to enable accurate observations to be made (Danermark et al., 2002). Despite the fact that observation is not always possible, evidence exists that events which are not observed do indeed occur. This suggests the existence of another domain consisting of all events which may occur, including those which do occur and are not observed. Further, observations may suggest that there are relationships between some events and other events, such that one event somehow forces or causes the other event to occur (Abbott, 1992). Often, the exact nature of the mechanism by one event causes the other may not be visible. That suggests the existence of a third domain, one in which entities which explain the connections between events reside. In CR, these three domains are termed the Empirical, Actual and Real, respectively.

The evidence for the ontological model of the world posited by CR can be illustrated using a thought experiment, adapted from (Gopnik, 2013).

Imagine you are in a room with a light switch that can be switched to one of two positions, and a light bulb. You observe that if the light switch is flipped to one position, the light bulb turns on, if it is switched to the other position, the bulb turns off. You can observe the pattern of events that occur, and recognize

that there appears to be a relationship between the event of moving the light switch, and the event of the light bulb turning on or off. This is evidence for the existence of the domain of the *Empirical* – the domain of observations.

You then observe that when you come into the room, the light bulb is either on or off, despite the fact that you have not seen the switch moved. Sometimes when you are leaving the room, you see the switch turned off, but when you later enter the room, the switch is turned on, even though you did not see it turned on. This is evidence for the existence of the domain in which all events occur, a domain which includes, but is a superset of, the events which are observed. This is evidence for the existence of the domain of the *Actual* – the domain of events.

However, with further observation, you may realize some anomalies. You may observe that on some occasions (such as during a power outage) moving the switch does not have the previously observed effect on the light bulb. You may also find there is another room in which there is a light bulb, but no switch. The bulb in that room operates despite the absence of a visible switch. It becomes clear that there is an underlying mechanism by which the switch is linked to the bulb. A simple rule: “flip switch = bulb turn on; and vice versa”; can not explain the link between the bulb and the switch. It is necessary to explain the underlying mechanism so that all the events that are observed can be explained. This is evidence for the existence of the domain of the *Real* – the domain of the underlying mechanisms.

A number of ontological concepts are fundamental to CR and the model of the world that it represents. They include:

- *Structures* – are a “set of internally related objects or practices” (Sayer, 1992, p. 92). They constitute the entities that are the objects of knowledge (Danermark et al., 2002), and can be material, social or conceptual in nature. Structures may contain component structures, and may themselves be part of a larger structure (Easton, 2010). Social structures have several characteristics that distinguish them from the structures that are typically studied in the natural sciences: unlike physical structures they do not exist independent of the agents that constitute them, and they both enable and constrain social action by those agents.
- *Mechanisms* – are capacities for action that are inherent to certain structures. Bhaskar (1975) describes them as “ways of acting of things”. Mechanisms exist in the domain of the real, and thus exist whether they are enacted or not. A gun has the power to shoot whether or not it is fired. Mechanisms’ capacity for action may be expressed either as *powers* or *tendencies*. Powers are the ensemble of capabilities that are present within an entity. Tendencies are the actions that are typical of a given entity: “All men (living in certain kinds of societies) possess the power to steal; kleptomaniacs possess the tendency to do so” (Bhaskar, 1975).
- *Events* – are the specific actions which result as a consequence of the activation of one or more mechanisms. In CR, events are ontologically distinct from the mechanisms that generate them

(Danermark et al. (2002) citing (Bhaskar, 1975)). Events can be shaped by the capacity for mechanisms to counteract, cancel or accentuate the effects of other mechanisms, leading to the possibility of both multifinality and equifinality in terms of the action of mechanisms and their outcome in events.

- *Experiences* – are that subset of events which are directly observed by human actors, either through sensory perceptions or via sensory-enhancing instruments. Some events may not be directly perceptible, but may be indirectly discerned through observation of subsequent perceptible events generated by them. Alternately, they may be made perceptible by the design of scientific experiments to ‘close the open system’ of reality so that the enactment of a mechanism leads to an observable outcome event. However, in the real world (particularly in the realm of social structures) such closure is rare, and direct observation of unobservable structures is rarely possible (Bhaskar, 1975; Danermark et al., 2002).

The goal of Critical Realist research is to use observations of experiences in the Empirical domain to probe events in the Actual domain, in order to, ultimately, understand the mechanisms operating in the domain of the Real. This goal is enacted by observing an overarching set of ontological and epistemological principles which inform CR research. Those principles will be explicated in the following sections.

### **3.3.3 Epistemology**

The ontological assumptions of critical realism lead to a set of epistemological principles which lay out the principles for accepting evidences for truth, given CR assumptions.

The following are the epistemological assumptions which emerge from CR principles according to Wynn and Williams (2012):

- *Mediated Knowledge* - CR posits that scientific knowledge exists in two domains: an intransitive domain, which contains the elements of the world which the scientist seeks to explain, and a transitive domain, which contains observations, theories, and scientists’ conclusions about the world. CR acknowledges that there is likely to be some mismatch between the contents of the two domains – i.e., that human knowledge, including scientific knowledge, is fallible. However, CR does posit that scientific knowledge will become ‘less fallible’ over time, and explicitly rejects the notions of some philosophers that no type of knowledge can lay claim to greater validity than other types of knowledge (Danermark et al., 2002). For example, at one point in human history, it was commonly believed that the world was flat. At a later point in history, it was believed that the world was spherical. Both of those beliefs were wrong (the earth is an oblate spheroid (Williams, 2014)), but critical realists would accept that one is more wrong than the other.
- *Explanation, Rather Than Prediction* – Because of the possibility that mechanisms will interact, causing different outcomes at different points in time, critical realism eschews the common

positivist goal of predicting that events will occur given a set of precedent factors. Also, because CR assumes that there is a reality independent of the human observer, CR studies do not give first priority to understanding the subjective meanings of events from the observer's point of view. Rather, CR studies seek to explain what happened in a particular research context by describing the causal mechanisms that led to the outcome. It is notable that CR does allow for the possible occurrence of regular outcomes via the operation of mechanisms, which are known in CR as demi-regularities or *demi-regs* (K. D. Miller & Tsang, 2011; Mingers, 2003a). However, observing *demi-regs* is never sufficient explanation for a phenomenon in CR, an explanation must describe the causal mechanism that is linked to the phenomenon (Tsoukas, 1989). Also, it may be possible to make sound predictions through an understanding of the underlying mechanisms which are explained in research, but the first goal of a CR study will be explanation, which may then lead to those other outcomes.

- *Explanation Via Mechanisms* – The concept of the use of mechanisms as an explanatory strategy for describing phenomena – especially phenomena that deal with causal relationships – is well established in the sciences (Abbott, 2007; Avgerou, 2013; Bechtel, 2008; Bechtel & Abrahamsen, 2005; Boden, 2004; Bunge, 1997; Angelika Dimoka & Davis, 2008; Hedström & Ylikoski, 2010; Nambisan et al., 1999; Piaget & Seagram, 1969). Critical realism is only one way of applying the mechanism-based perspective (see Hedström & Ylikoski, 2010), but the notion is central to CR. The explanatory approach, however, is common in the physical sciences. For example, “Biologists explain why by explaining how” (Bechtel & Abrahamsen, 2005). A CR study aims to explain an event or set of events by describing the mechanism or set of mechanisms that will explain those events. The CR researcher attempts to answer the following question “What must reality be like in order for this event to have occurred?” (Wynn & Williams, 2012). The study will therefore aim to describe the mechanism, describe the effect of antecedent factors on the mechanism, and show how the mechanism as described led to the event(s) that are the focus of study.
- *Unobservability of Mechanisms* – Causal mechanisms may be directly observable, but often they are not (Bhaskar, 1975; Easton, 2010). The fact that mechanisms may not be perceptible or measurable with human senses or available instrumentation means that their existence must often be inferred from their effects rather than directly observed or measured.
- *Multiple Possible Explanations* – Because causal mechanisms are often not directly observable, there will sometimes be more than one possible mechanism that could be responsible for causing an observed outcome. In such a case, CR researchers employ *judgment rationality* – comparing different possible explanations and selecting the one with the greatest explanatory power.

The epistemological principle of multiple possible explanations is an indicator of a fundamental issue in CR – that of *multifinality* and *equifinality*. In an open system, it is possible for more than one mechanism to lead to the same outcome, and it is also possible – because mechanisms can interfere with each other – for the same mechanism to lead to different outcomes. This disjunction between

mechanisms and outcomes means that mere statistical correlation is never sufficient to prove causality or evidence of a mechanism (Sayer, 1992; Tsoukas, 1989).

### 3.3.4 Methodology

Wynn and Williams (2012) have recommended five methodological principles for conducting CR research. These principles are based on prior research and emerge from the aforementioned ontological and epistemological assumptions. It is important to note that they are not steps – intended to be applied linearly in a single analytical process. Rather they are interdependent and interlinked, and are applied through parallel processes throughout the project.

- *Explication of Events* – The process of CR analysis begins with a comprehensive description of the events which led to the phenomenon, happening or outcome under investigation (Wynn & Williams, 2012, p. 79). This step can include thick descriptions of the events, sequence of actions, aggregation of actions, reinterpretation to expose structural elements or causal factors, and reframing through the lens of existing theory. The goal of this step is to develop a framework, through the detailed account of the events under study, for fulfilling the other methodological principles.
- *Explication of Structure and Context* – While in the Explication of Events element of the analysis we seek to expose the structural elements or causal factors which led to a sequence of events, in the Explication of Structure and Context we attempt to identify and resolve those elements of structure that are causally relevant to the outcome under investigation. This can involve analytical decomposition of higher-level structures, probing causal linkages between structures and events, and abstracting component parts of structure in light of existing theories to provide leverage for potential explanations. It is to be noted that a full description of all the elements of structure present in any real-world research context is unlikely to be possible within the scope of any practical study. A part of the researcher’s role is to decide which elements of structure are most relevant to the study, given the research questions and goals of the project.
- *Retroduction* – The central goal of a critical realist study is to describe the – often unobservable – causal mechanism/s which have led to the outcome under investigation. Retroduction is an abductive logic that proposes the existence of mechanisms which, if they existed, would explain the observed outcome, given the contextual conditions. It seeks to answer the question “What must reality be like for [phenomenon of interest] to have happened?” (Danermark et al., 2002). The researcher addresses this question by conducting multiple thought trials (Weick, 1989), and using multiple analytical strategies. This process may produce multiple possible sets of mechanisms which may have led to the observed outcome. The goal of the study is to identify that set of explanations (system of mechanisms) which offer the most complete and logically compelling explanation for what occurred (Wynn & Williams, 2012).

- *Empirical Corroboration* – The mechanisms proposed through the retroductive process are hypotheses. They are necessarily tentative in nature. Empirical corroboration is the process of comparing the hypothesized mechanism/s with data to verify their causal depth and explanatory power. It is also the process through which possible alternate explanations for observed outcomes are tested and the most logically compelling explanation identified. One of the logical tests that may be used to test explanations (i.e., mechanisms or sets of mechanisms) is their ability to provide consistent causal explanations for outcomes across multiple events or cases. This test is similar to the logic of pattern matching proposed by Yin (2009) or the concept of summative validity proposed by A. S. Lee and Hubona (2009). However, unlike the case in the MPMT logic proposed by A. S. Lee and Hubona (2009), a single case of the proposed mechanism failing to produce the expected outcome would not automatically disprove the existence of the mechanism, given the CR Open Systems ontological perspective.
- *Triangulation/Multimethods* – A basic implication of the critical realist model of reality is that the social world is made up of a variety of types of structures (conceptual, social, cognitive, physical, etc.), which have a variety of powers and tendencies, operating at a number of levels (individual, group, societal, etc.). Many of these structures are inherently unobservable and cannot be experienced except through their effects. It stands to reason from this that in order to understand the causal mechanisms formed by these structures, it is useful to engage a number of different modes of observation. This practice is useful because relevant evidence about structures that is difficult to apprehend with one method may be easier to collect with another. It also has the benefit of reducing the effects of bias. The use of a variety of data types, analytical methods and investigators is therefore recommended in CR studies.

Wynn and Williams (2012) note that there are three aspects of case study research that distinguish CR studies from positivist (e.g., Yin, 2009) or interpretivist (e.g., Walsham, 1995b) studies. The first concerns the research questions, which must be of the form “What caused the event associated with the phenomenon to occur?” This requires addressing how and why questions which fit well with the focus of this study. The third distinguishing feature of CR studies concerns the issue of generalizability. CR studies are not concerned with statistically generalizing from samples to populations, but are exclusively concerned with discovering and explaining causal mechanisms which are hypothesized to have generated the observed outcomes in a case. These mechanisms may then be retrodictively applied to other situations in which they may be causally active (Wynn & Williams, 2012, p. 799). This means that CR studies are concerned with theoretical generalization (Lee & Baskerville, 2003; Yin, 2009).

The second distinguishing characteristic identified by Wynn and Williams (2012) deserves attention. They assert that in case selection, CR studies are concerned with identifying the unique set of specific influences which resulted in the generation of a specific set of outcomes. This means that CR case studies will typically focus on idiographic studies of single structures (e.g., a single company) and will typically

focus on a single case, or a limited set of cases. This enables CR researchers to build detailed, context-sensitive explanations of phenomena (Wynn & Williams, 2012, p. 804), but it also appears to suggest that CR researchers will rarely, if ever, employ theoretically sampled multiple-case research designs. This conclusion would, if so, seem at odds with the goal of science in general, and CR researchers in particular: to make general statements about the world and generate theories that are of practical use in multiple settings (Bhaskar, 1975; Danermark et al., 2002; Mingers, 2006). However, this assertion by Wynn and Williams (2012) must be addressed. The challenge that they allude to is a real one: to identify the unique set of structural influences that are held to be causally relevant can be challenging in even a single research context. To look at why this is, we can return to the earlier thought experiment regarding the light bulb and the switch. If we set out to investigate the causal mechanisms that explain the relationship between the light bulb and the switch, which mechanisms would we investigate?

We could investigate mechanisms of electrical circuits and wiring, and trace the connections between the light bulb and the switch. Or we could investigate the mechanisms behind the construction of the building – mechanisms which include the actions of the architects, engineers, construction workers and electrical contractors who put the building together such that there is a relationship between bulb and switch. Or we could look at a completely different set of mechanisms concerning the way in which building codes and government regulations concerning the standards for electrical components in buildings have shaped the way this bulb and this switch have been designed. Or we could look at the historical story of the invention of the light bulb; or we could look at the way in which electrons move through circuits to provide power to light bulbs when switches are flipped. Or we could look at the design of the power grid, such that the circuit on which the bulb and switch are located is energized so that flipping the switch turns on the bulb. There are other ways in which we could investigate this as well, an almost infinite number of them.

None of the approaches outlined above would be *wrong* in the strict sense. Each of them could form the basis for defining one type of relationship between the bulb and the switch. However, it is also obvious that addressing them all would be beyond the scope of a single study. Which set of mechanisms a particular set of researchers would find to be causally relevant in a particular study depends on a number of factors, including the theoretical orientation of the researchers (e.g., are they engineers or historians?), and the specific areas of focus of the study. This challenge is one of *structural analysis*, that Wynn and Williams (2012) identify as part of the Explication of Structure and Context principle (Wynn & Williams, 2012, p. 799). They note that a full accounting of all the powers and tendencies of various structures present in any research context would be so large as to be impractical. The question is, given the rigors of structural analysis, even in a single setting, how can a CR approach be applied in multiple case studies?

The key to addressing this issue is alluded to by Wynn and Williams (2012, p. 799), as well as by Hedström and Ylikoski (2010): the use of existing theory to provide a framework for analyzing the data in each case context, so that the detailed events in each case can be abstracted away and the structures under

investigation can be observed in action. This is the approach that will be applied in this study. A theoretical framework for analyzing the appropriation of IT systems will be used to assist in the structural analysis of each case.

### **3.4 Critical Realist Research in IS**

Critical realism has been recommended as a metatheoretical position for IS researchers by a wide range of theorists, including Mingers (2004c), Dobson (2001), and Markus and Silver (2008). A growing number of empirical studies have emerged which take an explicitly critical realist position, including (Bygstad, 2010; Bygstad & Munkvold, 2011; Dobson et al., 2007; Faulkner & Runde, 2013; Henfridsson & Bygstad, 2013; Morton, 2006; Volkoff & Strong, 2013; Volkoff et al., 2007). In addition, critical realism has been playing an important role in the development of theoretical approaches within IS.

Frameworks for applying critical realist assumptions in IS research have been proliferating in the literature. They include (Dobson, 1999; Easton, 2000; Tsang, 2012, 2013a) on case study methodology, and Mingers (2003a) on statistical methods. Critical realism has also been proposed as a means for reframing and addressing long-standing theoretical debates within the discipline as a whole. This body of work includes Smith (2006) on theory-practice inconsistencies in IS research; Mutch (2013) on sociomateriality; Venkatesh, Brown, and Bala (2013) on bridging the qualitative-quantitative divide; and Mingers (2003b) on the use of multiple methods. This critical attention works in both directions as IS researchers have proposed methods for extending critical realism by developing methods for testing critical realist theories (K. D. Miller & Tsang, 2011). In addition, critical realism has been getting significant attention from the field's leading journals (Mingers et al., 2011); (Straub, 2011).

One reason for this surge of interest is the apparent match between the methods of CR and the need of the IS field to investigate phenomena that occur at the intersection between material artifacts and human agents (Markus & Silver, 2008). Another is the significant existing theoretical literature (Bhaskar, 2008; Danermark et al., 2002; Sayer, 1992, 2000), and the broad tradition of applying critical realist assumptions in other applied fields (Faulkner & Runde, 2013; Fleetwood, 2005; Kwan & Tsang, 2001; Runde, 1998), as well as the — seldom acknowledged — critical realist foundations of popular methodological approaches in IS (Cook, Campbell, & Day, 1979; Miles & Huberman, 1999). Critical realist positions have also been taken on several prominent debates in the discipline, being the foundation for Mutch (2013)'s challenges to sociomateriality, Mingers (2003a)'s critique of statistical modeling in the field, and Tsang and Williams (2012)'s challenges to accepted norms for generalization and induction. One of the most influential recent critiques of the norms for representing system use in IS research, Burton-Jones' dissertation (Burton-Jones, 2005), and subsequent publications on the topic (Burton-Jones & Gallivan, 2007; Burton-Jones & Grange, 2012; Burton-Jones & Straub, 2006), can actually be seen as an immanent critique of the representation of system use in the discipline.

There is also considerable evidence, suggested by Burton-Jones (2005, pp. 8-9), that many IS researchers who self-identify as positivist or interpretivist are actually using unacknowledged critical realist assumptions. The basic epistemological assumptions that the world is real, and that human knowledge of the world is socially constructed and imperfect, is implicit in much of the IS literature that does not carry the label “critical realist”.

### 3.5 Discussion

There have been many debates about the merits of CR in the literature. In IS, early proponents of CR included (Dobson, 1999, 2001) and Mingers (2004b). Like any philosophical position, it was challenged. In IS, the same issue of the Information and Organization that introduced (Mingers, 2004c), also presented critiques of the approach by Monod (2004) and H. K. Klein (2004) (see (Robey, 2004)). Mingers (2004a) responded to these critiques, and there is little doubt that debates about the relative merits of different philosophical positions will continue to be a feature of academic discourse for some time. In this section, I will briefly contribute to this debate, and defend the choice of a critical realist perspective for the thesis.

Some have challenged the CR perspective on the basis that some of its positions can be seen as similar to positions held by preexisting philosophical perspectives. One example is H. K. Klein (2004), who essentially challenges the ‘newness’ of the concepts in CR by showing that interpretivist assumptions can lead to some CR conclusions, and positivist assumptions can lead to others. However, in doing so, he seems to (perhaps inadvertently) support Mingers (2004a)’s claim that CR “does not ... just dismiss competing philosophies but tries to incorporate within itself that which is valuable” (Mingers, 2004a, p. 147). CR’s principal claim is not to the novelty and uniqueness of its positions, but rather the explanatory power of its ontological and epistemological assumptions when applied to real-world events.

Monod’s critique of CR revolves around what he perceives as anomalies in CR’s claims regarding the possibility of objectivity, the nature of causality, and the distinction between natural and social sciences (Monod, 2004, p. 106). Regarding objectivity and causality, as elegant as arguments about the necessity of observers for the existence of phenomena may be (see (Monod, 2004, pp. 107-109)), any distracted pedestrian who has walked into traffic (and lived) can testify that objects in the world are capable of having effects on an observer who is not aware of the existence of the object *a priori*. This argues for a realist conceptualization of phenomena. For example, IT can have effects whether the affected are aware of it or not (Markus & Silver, 2008). More to the point (of this thesis) the process involved in generating a creative outcome can involve events and phenomena of which actors involved are not aware. I should comment that while making this point Monod states that CR conflates statistical probabilities with laws, which it does not (Monod, 2004, p. 109), perhaps due to a misreading of Mingers.

Monod criticizes CR for the fact that it proposes the existence of generative mechanisms whose existence can neither be validated nor invalidated. He says that this puts CR into a state of *antimony* – a term from Kant that means “when [rationality] ventures beyond the boundary of experience”. However, great swaths of knowledge in the sciences are in fact, based on conceptual structures which are not ‘validated’. For example, in physics, the Standard Model was accepted and used as a basis for theorizing for decades before the existence of the Higgs Boson was ‘validated’ by the Large Hadron Collider (Cho, 2012). To limit the domain of “knowledge” only to those things which can be completely validated is not a viable approach to science. To demonstrate this, I present a formulation of a common thought experiment: the “Brain in a Vat” conjecture; a modernized version of Plato’s Cave, or the Cartesian Demon.

There are many versions of this conjecture, of which the most profound is indubitably (Patton, 1988). However, for this explanation a simpler version will suffice. It is as follows:

*Imagine that, while you slept, an evil scientist kidnapped you, extracted your brain, and put it into a vat of heated nutrient solution that will keep it alive. The evil scientist then connected your brain to a supercomputer which is programmed to replicate the signals which would normally be received by your brain during interaction with the external world (note that this formulation defeats Putnam (1981)’s refutation, see (Brueckner, 2012)).*

*The supercomputer has sufficient information about the real world to plausibly replicate all possible physical experiences within the world. How could you recognize or prove that you were actually just a brain in a vat?*

The short answer is that there is no apparent means by which one would be able to prove that one is a brain in a vat. Conversely, this means that it is not possible to prove that one is not currently a brain in a vat. If one cannot prove that one is not a brain in a vat, then one cannot prove that the external world exists (Dror & Harnad, 2008, p. 8). If one cannot prove that the external world exists, then one cannot prove that entities in the world exist. If one cannot prove that entities in the world exist, then one cannot prove that relationships between entities in the world exist. It is therefore impossible for any scientific theory describing entities or relationships, or any part of human knowledge, to be absolutely proved beyond all possible doubt. Since the existence of external reality cannot be validated or invalidated, it follows that *no* Knowledge can claim to be ‘validated’ in the sense that Monod refers to. Therefore the antimony test is not a useful one for testing knowledge claims – knowledge exists which cannot be ‘validated’.

The above suggests that in scientific research, since it is ultimately impossible to prove or disprove the existence of perceived objects (being), or perceived relationships between objects (causality), decisions about metatheoretical assumptions must ultimately be based on a researcher’s judgment. For the current

project, I have evaluated a number of possible positions, and must say I concur with the views expressed in (Easton, 2010, p. 128) regarding CR: I think it's assumptions reflect how the world is; even if they do not, I think that I (and many scientists), behave as if they do; I think it makes stronger arguments than competing positions; and I think it gives a well thought through and relatively coherent position on the nature of the world.

Critical realism will therefore be applied as the philosophical position of this project.

## Chapter 4. Research Design

### 4.1 Overview

There are two approaches one can take to empirical studies of creativity, according to Policastro and Gardner (1999). There is the cumulative approach, in which one takes as a starting point existing work in an area and builds upon it; then there is the phenomenon approach, one begins with the clearest available instance of the phenomenon under investigation, and then seeks to construct a theoretical explanation for it. Given the lack of existing research in IS on the creative appropriation of systems by users, the phenomenon approach is more appropriate for this topic, and will be applied in this study. Dunbar (1997) also proposed two basic approaches to answering questions about creative thought: *In Vitro* studies in which subjects are brought into cognitive laboratories for controlled experiments, and *In Vivo* studies, in which creative action is investigated in ‘real world’ settings. *In Vitro* research can lead to insights into the basic psychological mechanisms underlying complex thinking processes, while *In Vivo* work can lead to insights into the basic cognitive mechanisms underlying creativity in real-world contexts (Dunbar, 1997, p. 2). Given the understudied nature of creative appropriation, I selected an *In-Vivo* phenomenon approach, which will use insights gained from prior (*In-Vitro* and *In-Vivo*) studies to identify cognitive mechanisms. The overall design and execution of the study will be guided by a well-established methodological framework: Eisenhardt (1989a)’s framework for building theory from case study research.

As is common in qualitative research (Miles & Huberman, 1999), and consistent with the guidelines of the overarching research framework being followed (Eisenhardt, 1989a), the design of the study was emergent. The study was begun — as per Eisenhardt (1989a) — with a set of research questions, and an initial set of *a priori* constructs, but no pre-specified theory. The research questions and constructs evolved in response to findings in the data. Moreover, the metatheoretical assumptions underlying the study evolved, changing from classical positivist to critical realist, as has been done in previous research (Volkoff et al., 2007). As a critical realist approach was adopted during the study (this will be described in following sections), Eisenhardt (1989a)’s framework was integrated with Wynn and Williams (2012)’s principles for conducting critical realist case research. The research design will be described in this chapter.

I will begin with a description of Eisenhardt (1989a)’s framework for inducting theory from case study research. I will state the design parameters of the project and give an overview of the case study protocol (see Yin, 2009) that was followed at each of the case sites. A key feature of Eisenhardt’s framework is the requirement that the conduct of the study be responsive to discoveries made during data collection. I will describe the findings in an early case that resulted in the modification of the research question, and the subsequent adoption of critical realist assumptions for the analysis of the data and to shape the form of

the emergent theory. I will then describe the key analytical techniques that were applied to the data, and show how the iterative steps of Eisenhardt (1989a)'s framework were integrated with those of Wynn and Williams (2012)'s principles for critical realist case research in order to provide a logical and coherent design for the study.

## 4.2 Methodological Framework

This research will employ an embedded multiple-case design (Yin, 2009, p. 46). This design has been selected for the following reasons. First, the study aims to identify mechanisms that are part of the human cognitive system. These should be identifiable in a variety of contexts. Testing that assumption requires that the mechanisms be identified in one context, and observed in another context outside the one in which they were developed, a theoretical replication (Yin, 2009, p. 54). A multiple-embedded design permits this. Second, while using replication logic in single-case designs has been demonstrated (Markus, 1983), and has been defended as an acceptable and robust method for generating theory in IS research (A. S. Lee, 1989b), multiple-case designs can allow more control over theoretical sampling. Thirdly, multiple case designs have been described as generally preferable by some experts on case study methodology (Eisenhardt, 1989a; Yin, 2009). An implication of this design is multiple embedded units of analysis (Markus, 1983). In this study, the main unit of analysis will be activity-based: an incident in which a user or users appropriate a system in a creative manner. However, like Bourgeois III and Eisenhardt (1988b), I will have two other units of analysis: the individual participants in each case, and the organization within which the incident takes place.

The overarching framework that guided the conduct of this research project was the framework for inducting theory from case research developed by Eisenhardt (1989a). Eisenhardt's framework grew out of her own work on strategic decision-making (Bourgeois III & Eisenhardt, 1988a; Eisenhardt, 1989b; Eisenhardt & Bourgeois III, 1988), and aimed to make two contributions: to provide a roadmap for building theories from case research, one which synthesizes and extends previous work on qualitative methods, specifically (Miles & Huberman, 1994) (1984 version), (Yin, 2009) (1981 version), and (Glaser & Strauss, 1968); and to position theory building from case studies within the larger context of social science methods (Eisenhardt, 1989a, pp. 532-533). Eisenhardt's method can be regarded as one attempt to address a common problem in theory-building research: the fact that when theory-building is started from the foundation of a preexisting theory, that theory tends to bias the outcome of the theory-building exercise. To quote the common aphorism, *when all you have is a hammer, every problem looks like a nail*. Eisenhardt's roadmap attempts to address this problem by specifying precisely what elements of preexisting knowledge can be integrated into the study, and how, while eschewing the biasing effects of pre-specified theory. The major steps of Eisenhardt (1989a)'s framework are summarized below.

The framework proposes a set of steps which are carried out in roughly sequential fashion in order to go through the entire process, from preparing to conduct fieldwork to identifying the point at which the study is complete. The steps are “roughly” sequential in that some of them may be, and typically are, carried out iteratively (Eisenhardt, 1989a, p. 541). However, the project will typically follow the broad steps below.

1. **Getting Started** – defining research questions and, possibly, *a priori* constructs. No hypotheses or “theory” specified at this point
2. **Selecting Cases** – Should specify the research population, and employ theoretical sampling, as per (Yin, 2009)
3. **Crafting instruments and protocols** – multiple data collection methods, data types, and investigators for triangulation purposes
4. **Entering the field** – overlapping data collection and analysis. Opportunistic data collection methods
5. **Analyzing Data** – within and cross-case analysis
6. **Shaping hypotheses** – iterative tabulation of evidence; replication logic across cases; search for evidence of the “why” behind relationships
7. **Enfolding literature** – comparison with convergent and divergent literature
8. **Reaching closure** – sometimes dictated by pragmatic considerations, but ideally reached when theoretical saturation is attained

(Adapted from Eisenhardt, 1989a)

Eisenhardt (1989a) recommends that theory-building research is begun with clear research questions, and “as close as possible to the ideal of no theory” (Eisenhardt, 1989a, p. 536), in order to avoid biasing or limiting the findings. However, she also acknowledges that it is impossible to achieve the ideal of a clean theoretical slate. This is particularly so in light of her parallel recommendation that *a priori* specification of constructs should be considered, in order to shape the initial design of the research, as well as permit more accurate measurement of those constructs than would otherwise be possible. Both the initial constructs and the research questions are regarded as tentative at the beginning of the research.

The initial constructs applied in this project were drawn from the componential theory of creativity specified by Amabile (Amabile, 1983, 1996; Amabile et al., 1996) and later extended by Fisher and Amabile (2009). This theory was selected due to its extensive grounding in empirical work, and for the range of research domains in which it has been applied: from research labs (Amabile, 1983) to field research in R&D departments (Amabile & Gyskiewicz, 1987) and general organizational-level creativity research (Amabile, 1988). It has been developed and tested through rigorous experimental work, in-depth qualitative field studies and longitudinal quantitative survey research (Amabile, Hill, Hennessey, & Tighe, 1994). The overarching finding of this program of research is that creativity, at all levels, results from the

intersection of three components (Amabile, 1988, 1996). The components, and their specific instantiations at both the individual and organizational levels, are listed in the Creativity section of the preceding chapter.

The codes from (Amabile, 1988, 1996) formed the initial set of *a priori* constructs that were used to code the first set of data that were collected at the field sites. The set of codes applied in the initial part of the study are listed in Appendix 1.

#### **4.2.1 Case Selection and Protocols**

One recommendation from Yin (2009), echoed by Eisenhardt (1989a), is that a case study protocol be developed and implemented in the study. This is particularly important in multiple-case studies, as it controls variation in the data collected across case sites, and so permits the application of replication logic in cross-case analysis. For this study, a formal case study protocol was developed and followed. The protocol is summarized here.

##### **Case Selection**

In the type of case study research represented by (Eisenhardt, 1989a), one of the critical issues is that of determining the criteria to be used for case selection. This type of research employs theoretical sampling – the deliberate selection of cases to fill theoretical categories in order to provide illuminative explanations (Eisenhardt, 1989a, p. 537). A distinguishing characteristic of such case research is the application of replication logic (Yin, 2009). Cases may be selected in order to replicate significant conditions – literal replication; or they may be chosen in order to systematically vary significant conditions in order to test the effects of such variation – analytical replication. In order to properly apply replication logic, Eisenhardt (1989a) recommends that case selection begin with the defining of an appropriate population, to control extraneous variation in the data, and to help define the limits for generalizing the findings. For this study, the defined population was users of non-hedonic systems for tasks in work-related contexts.

In each case site, a standard case study protocol was followed, as recommended by Yin (2009). The following procedures were followed at each case site.

##### **Case Elicitation**

When beginning to work on site, the first activity involved educating the investigator about the participant organization: the basic functions of the organization and target unit, unit structure, as well as the formal and informal norms that may assist in eliciting data from participants in the group. This process – known as *bootstrapping* (Crandall, Hoffman, & Shadbolt, 1998) – was accomplished through unstructured interviews with a key informant within the organization. The key informant was asked for basic information about the systems in use in the organization. Two major questions were asked of this

informant: “What is the most important thing that this organization does?” and “What IT systems are used to do it?” These questions are intended to identify the most strategically important systems in the organization. It was surmised that the systems that are used for core business-process tasks in each organization will generate the most interesting cases of creative appropriation. Strategically important systems used for a core business process were selected as the systems whose users would be selected as potential interviewees.

Users of these systems were then asked to describe an incident they knew of in which themselves, or someone else, developed or discovered a novel way to use the system: one that “would probably surprise the developers of the system if they heard about it.” Stories about the discovery or development of novel ways of using the system were collected, and some of those stories were selected for deeper investigation. For those incidents selected for further investigation, the major participants in the incident were asked if they would consent to be interviewed. No incident was chosen for deeper analysis if two conditions were not met:

1. At least one of the major participants in the incident had to be available for interview, and
2. There had to be more than one data source for triangulation.

For those incidents selected for deeper investigation, opportunistic collection of all available types of data was done (Eisenhardt, 1989a). However, the principal source of data in each case was semi-structured interviews with involved participants. The semi-structured interviews utilized cognitive task analysis techniques, as described below.

#### **4.2.2 Cognitive Task Analysis**

The primary data collection method used in the study was semi-structured interviews of users who have participated in an incident of creative appropriation. The interviews served to provide an understanding of the task domain within which the system was used, and the participant’s perspective of the story of how the novel way to use the system emerged.

One approach to discovering the nature of task domains and eliciting the knowledge of individuals that function in those domains is cognitive task analysis (Crandall et al., 1998; Kahneman & Klein, 2009). Cognitive task analysis has been applied in the elicitation, preservation and dissemination of expert knowledge and is widely used in the design of expert systems and knowledge bases. Although cognitive task analysis is sometimes referred to in the literature as though it were one technique (Chipman, Schraagen, & Shalin, 2000; Schraagen, Chipman, Shalin, & Shalin, 2000), the term actually refers to a family of distinct methods that are used for knowledge elicitation. These methods are commonly used to identify the cues and strategies that guide expert professionals as they perform in their domains of

expertise, even when such performance draws on tacit knowledge that it would be hard for the experts to articulate (Kahneman & Klein, 2009, p. 516).

After a review and consideration of several cognitive task analysis techniques, one was selected that was judged to be a good fit for the knowledge elicitation needs of this study. It is described below.

### 4.2.3 The Critical Decision Method

One of the methods used in cognitive task analysis is the Critical Decision Method (CDM) (Crandall et al., 1998; G. A. Klein, Calderwood, & Macgregor, 1989). The technique involves case-specific, multi-trial retrospection guided by probe questions. It was developed to capture the kinds of knowledge and expertise applied in real-world decision making and problem solving (Crandall et al., 1998, p. 255). The full CDM procedure typically takes two or more hours to complete. However, the method is designed to be flexible and adaptable to the requirements of the study in which it is applied. An adaptation of the CDM procedure was used to elicit the details of the incident in which the system was appropriated creatively, in a way that addresses the research questions of the study, without collecting extraneous information (Miles & Huberman, 1999). To increase the likelihood of successfully eliciting all relevant details during the interviews, the guidelines for conducting qualitative interviews proposed by Myers and Newman (2007) were followed. The adapted CDM interview protocol which was used in the interviews with participants is below:

**Table 2: Adapted Critical Decision Method Protocol**

#	Question	Rationale
1	Can you tell me about your job and how you came to work here?	Manages <i>Entry</i> by setting the stage. Beginning with this simple descriptive question allows the interviewer and interviewee to acclimatize to playing their roles. At the same time, this question collects some background information about the interviewee that may speak to their motivation and skills when combined with data gathered in later questions.
2	How did you decide to be a <task role> and what kind of training did you do for it?	This question continues to set the stage and let the actors ‘warm up’ for the main performance. At the same time, it elicits salient background information about the interviewee and enables some discovery of what background experiences and skills on the actor’s part may have shaped the incident.
3	With regards to <creative appropriation incident>, can you walk me through how it happened, from beginning to end?	First step from the Critical Decision Method (CDM): <i>Incident Recall</i> . The interviewer asks few, if any, questions and allows the interviewee to structure the account.

4	<i>Interviewer tells the story back, matching as closely as possible the interviewee’s own phrasing and terminology</i>	Second step from the CDM: <i>Incident Retelling</i> . The interviewer tells the story, matching as closely as possible the interviewee’s own phrasing and terminology. The interviewee will typically offer additional details, clarifications and corrections during this process. This allows the interviewer and interviewee to arrive at a common understanding of the incident.
5	<i>The interviewer leads the interviewee back over the incident a third time, employing probe questions that focus attention on particular aspects of the incident.</i>	The third step from the CDM: <i>Progressive Deepening</i> . A selection of the probes that are specified as part of the CDM are used to further investigate details of the incident that are judged relevant to creative use.
6	Is there anything else you feel I ought to know in order to understand <creative appropriation incident>?	Elicits further insights that the interviewee may have about the incident under investigation. Sets the stage for the <i>Exit</i> phase of the interview

The protocol followed in the interviews with participants was as follows. Each interview was begun with two simple descriptive questions to ‘break the ice’, to get the interaction between the researcher and interviewee started, as well as to elicit background information from the participant. There next followed three items adapted from the Critical Decision Method: Incident Recall, Incident Retelling, and Progressive Deepening. In the progressive deepening step, I used probe questions – as specified in the CDM – to elicit details that were salient to the research questions, if those details had not already emerged in the account of the incident. A full list of the probes specified with the CDM is listed in Appendix 2. The final question was designed to elicit any insights into the incident that the interviewee may have which was not covered in the interview, as well as to prepare for the Exit stage of the interview-as-drama (Myers & Newman, 2007).

It must be emphasized that the above procedure elicits raw data for analysis, rather than direct answers to the research questions. Kahneman and Klein (2009) note that researchers cannot expect decision makers to accurately explain why they made decisions. Research indicates that there may be little or no direct introspective access to higher order cognitive processes (Nisbett & Wilson, 1977). Memory and reflective processes are subject to bias and error (Kahneman, 2011), and this becomes especially problematic in the mental attribution of creative processes (Csikszentmihalyi, 1997; R. K. Sawyer, 2007). The Critical Decision Method, like other cognitive task analysis techniques, simply provides a basis for making inferences about judgment and decision processes.

To support those inferences, a number of data sources, in addition to interviews with participants, were collected and analyzed. They include documentation, instructions and reference materials for the systems; training materials that may have influenced participants; online documentation, including release notes and changelogs; direct observation of use of the system and operations in the system context; and reviews of public information about the organizational and social contexts in which the creative actors operate.

The use of multiple types of data sources is an integral part of the case study method and was carried out using standardized techniques as suggested by (Miles & Huberman, 1999; Yin, 2009).

#### **4.2.4 Quasi-Experiments**

Controlled experiments conducted in laboratories are often considered the “gold standard” for establishing causal relationships in scientific research. In such experiments, treatment conditions are systematically varied by the researcher. Participants in experiments typically get exposed to different levels of the treatment, and differences in outcomes are observed. The key to controlled experimental design is that while the treatment is varied, all other variables are (as far as possible) held constant by the researchers, causally linking types or levels of outcome to levels of treatment. Lab experiments have high internal validity, but often purchase that at the cost of low external validity because of the artificial conditions in which they are conducted. This is of particular concern in a study concerning the mechanisms involved in creativity. For example, analogical thinking — which is regarded as an important element in many stories of creative discovery — is known to occur much more readily in naturalistic settings than it does under experimental conditions (Dunbar, 2001).

However, Yin (2009) suggests that replication logic — the kind of reasoning which underlies the experimental method — can be used in circumstances where “natural experiments” occur: that is, where naturally occurring conditions allow the same kind of linking between treatments and outcomes that is done in full-fledged laboratory experiments. In these circumstances, some critical differences between the classic experiment and the naturalistic situation include the inability of the researcher to randomly assign participants to levels of the treatment condition, and the inability to control extraneous variables. This leads to lower internal validity, but has greater external validity because of the non-artificial context. This type of research design is known as a quasi-experiment (Bhattacharjee, 2012; Cook et al., 1979). Quasi-experiments (or field experiments) trade some of the control in lab experiments for external validity, as they occur in field settings (K. D. Miller & Tsang, 2011, p. 150). While quasi-experimental designs can be used in situations where the treatment condition is varied by the researcher, quasi experimental logic can also be used where the treatment condition varies naturally across cases (Szulanski & Jensen, 2004). Using this kind of replication logic across cases is a well-accepted analytical technique in IS (A. S. Lee, 1989b) and has been used in widely-cited studies in the discipline (Markus, 1983).

In the case data, some naturally-occurring events were found that facilitated the use of experimental logic to analyze what happened (Yin, 2009, p. 12). This is not a central method designed into the study, but is used opportunistically, as recommended in the (Eisenhardt, 1989a) framework. The ability to accommodate such flexibility in mid-study is a key benefit of the case study strategy for theory-building research. In the current project, a circumstance was observed in one of the participant organizations which conformed to the design of a quasi-experiment. The circumstance was naturally-occurring and no manipulation by the researcher was involved. However, the situation was noted and quasi-experimental

logic was used to analyze the data. The results are used as a data point to support the overall findings of the study.

### 4.3 Evolution of the Design

As previously stated, this study initially followed the roadmap proposed by (Eisenhardt, 1989a). Eisenhardt's framework follows a series of steps which take the researcher from defining the research questions through closure. However, it is also designed to accommodate changes during the research process, in response to such events as unexpected patterns in the data which require further exploration, or unanticipated opportunities which arise for collecting new data. The goal of building good theory means that understanding the case data in depth takes precedence over following a predefined research plan. Eisenhardt (1989a, p. 539) explicitly endorses making mid-course adjustments to the design in response to preliminary findings in the data. This "controlled opportunism" gives the flexibility to make adjustments in order to improve the theory.

During the investigation of the second case site visited during this study, an unexpected finding emerged that provided such an opportunity. In an organization that has been assigned the pseudonym "Theta" there were a number of characteristics which suggested that a great deal of creative appropriation would be found in the organization. Theta is a small and dynamic firm which is in a creative industry (they develop a certain type of software), and has a culture of innovation and experimentation. In my bootstrapping interview with the Chief Innovation Officer at Theta, he showed me several examples of products that they had developed which had no commercial application — just "to see if we could do it". Developers at Theta are highly skilled and have great deal of autonomy in terms of how they work. Theta is a highly successful company, and has performed work for international industry leaders in their sector. They are also, within certain limits, free to choose the tools they feel most comfortable with. I expected, and so did the CIO, that there would be a significant number of interesting cases of novel appropriations of technology at Theta. The CIO and the rest of the management team checked, and found nothing. The managers were surprised by this result and re-surveyed the firm. They were unable to find any instances in which users within Theta had appropriated their tools in a non-standard manner. Given the fact that the Theta developers had Resources, such as technical skills and special talents; Techniques, such as work styles and management practices which were tailored to creativity; and Motivations for creative production such as creative drive (as reflected in their many successful projects) and reward structures that were aligned to creative action (Amabile, 1983, 1996); this finding was unexpected.

I realized that a case like Theta — in which creative appropriation does *not* occur, despite the apparent presence of factors which may be expected to encourage creativity, could potentially explain a lot about creative appropriation. More importantly, it could also demonstrate, and help to explain, what ontological differences there might be between creative appropriation and other kinds of creativity. However, the

originally-planned approach — that of iteratively amassing lists of factors involved in successful cases of creative appropriation and integrating those factors into a synthetic variance model (Langley, 1999) — would not make adequate use of data from cases like Theta. In fact, if one is looking for factors which lead to creative appropriation, then where there is no case, there are no factors. Data from interesting situations like that at Theta would be lost.

As a result of Theta, and other participant organizations at which there were unexpected results (the participant organizations and cases will be summarized in the next chapter), I decided to change the proposed form of the theory to be developed from synthetic variance (Langley, 1999) to mechanism-based (Hedström & Ylikoski, 2010). A mechanism-based strategy can “detail the cogs and wheels of the causal process” (Hedström & Ylikoski, 2010, p. 50), and can integrate different types of data from different types of outcomes. Mechanism-based theories can be built using a variety of philosophical assumptions, and the strategy is not dependent on critical realism (see Hedström & Ylikoski, 2010, pp. 56-57). However critical realism does have the mechanism-based strategy at its heart (Wynn & Williams, 2012), and has been recommended as a suitable ontology for use in IS (Markus & Silver, 2008).

Eisenhardt (1989a) acknowledges that her framework exhibits a positivist orientation. However, as I will demonstrate in the next section, the assumptions of her theory are, in fact, realist, and are compatible with CR. There are also examples in the literature of studies in which researchers have begun with one orientation or method, then changed to a critical realist perspective during analysis in order to take advantage of its rich models of causality, as Volkoff et al. (2007) – an exemplary critical realist study in IS (Wynn & Williams, 2012) – did when they used a critical realist lens to study data they had gathered using grounded theory as a method. I therefore decided to use a critical realist perspective to produce a mechanism-based explanation of creative appropriation. This led to the following adjustments to the study design.

#### 4.4 Integrating the Approaches

As previously discussed, the (Eisenhardt, 1989a) roadmap posits eight steps, from the development of the initial research questions to the completion of the study. They are:

1. **Getting Started** — defining research questions and, possibly, *a priori* constructs. No hypotheses or “theory” specified at this point
2. **Selecting Cases** — Should specify the research population, and employ theoretical sampling, as per (Yin, 2009)
3. **Crafting instruments and protocols** — multiple data collection methods, data types, and investigators for triangulation purposes
4. **Entering the field** — overlapping data collection and analysis. Opportunistic data collection methods

5. **Analyzing Data** – within and cross-case analysis
6. **Shaping hypotheses** – iterative tabulation of evidence; replication logic across cases; search for evidence of the “why” behind relationships
7. **Enfolding literature** – comparison with convergent and divergent literature
8. **Reaching closure** – sometimes dictated by pragmatic considerations, but ideally reached when theoretical saturation is attained

Wynn and Williams (2012) in their framework for conducting critical realist case studies, lay out five ‘principles’ for conducting such studies. They are:

- A. **Explication of events** – identify and abstract the events that are part of the phenomena being studied
- B. **Explication of Structure and Context** – Identify the structures (in the domain of the Real) that are part of the events being studied. Also identify relationships among the structures and elements of the environment which are relevant to the phenomenon being studied. Theoretically redescribe the events under analysis from the actors’ viewpoint to a theoretical perspective
- C. **Retroduction** – Identify and describe the powers and tendencies of the structures identified (i.e., the mechanisms), which may have generated the events that have been explicated and redescribed
- D. **Empirical Corroboration** – Ensure that the identified mechanisms have sufficient causal depth to form plausible explanations for the observed events. Also ensure that they provide better explanations than possible alternatives
- E. **Triangulation and Multimethods** – Employ multiple approaches, viewpoints, tools and perspectives in order to strengthen the causal explanations

I set out to integrate both frameworks. Before examining them to see if they were *structurally* compatible, I first examined their underlying assumptions to see if they were *epistemologically* compatible. Eisenhardt (1989a) is explicit about the philosophical assumptions that underlie her framework:

“... The process described here adopts a positivist view of research. That is, the process is directed toward the development of testable hypotheses and theory which are generalizable across settings.” (Eisenhardt, 1989a, p. 546)

She describes her approach as positivist, in that it is geared toward the development of theoretical representations which are *testable* and *generalizable*. A theory should be testable if it describes a property of external reality which is not merely a social construction of the researcher and can be examined from divergent perspectives. It should be generalizable if describes a property of the world which exists, and can have an effect in contexts other than the one in which it is initially observed. These are, at the core, *realist* assumptions. Eisenhardt (1989a) comes to them from a positivist position, and she emphatically

distinguishes her position from the constructivist perspective (see Eisenhardt & Graebner, 2007, p. 28); however her basic assumptions are compatible with realist positions in general, and critical realism in particular. Further, I note that although her philosophical orientation is explicitly positivist, several of her recommendations, such as the use of multiple data types and multiple investigators (Eisenhardt, 1989a, p. 538), demonstrate an implicit assumption of the subjective and fallible nature of human perception and measurement. This assumption has more in common with the critical realist assumption of epistemological relativity, than it does with classical positivist assumptions about measurement. This issue of *epistemological misattributions*, by practicing scientists who consider themselves positivist, but who hold assumptions more compatible with critical realist than classical positivist positions, has been discussed earlier in the thesis (Burton-Jones, 2005; Moldoveanu & Baum, 2002). There was therefore no epistemological reason why the frameworks should be incompatible.

I therefore turned to an analysis of the structure of the two frameworks. Both describe case study research, encompassing the studying of phenomena in their natural environment, the use of multiple sources of evidence and analytical methods, an iterative process of investigation and the development of theoretically abstract explanations of phenomena. They differ in the form of theory that is developed: Eisenhardt (1989a) aims to develop theory that can be expressed in a series of theoretical statements such as research hypotheses. Critical realist case research aims to identify and describe mechanisms in the domain of the real that explain (or *caused*) the events under study. Another important dissimilarity is that Eisenhardt (1989a), like Yin (2009), recommends the use of multiple cases to increase confidence in the study findings, where possible. Wynn and Williams (2012) do not discourage the use of multiple cases, but they do suggest that because of the rigors of structural analysis, most critical realist case studies will have limited contexts. This will be discussed below.

Eisenhardt (1989a) provides the overall framework for the empirical work that was performed. However, I discovered that Wynn and Williams (2012)'s principles for critical realist case research can integrate with the steps in Eisenhardt (1989a)'s roadmap for case research. Eisenhardt (1989a)'s first five steps, up to within-case analysis, all contain activities that can be subsumed under Wynn and Williams (2012)'s principle of Explication of Events: identifying *what happened* in each case. Eisenhardt (1989a)'s second activity within step five, cross-case analysis, can be subsumed under Wynn and Williams (2012)'s principle of Explication of Structure and Context: analyzing what underlying structures are common across cases, and theoretically redescribing events in the cases from a theoretical (structural) perspective. Eisenhardt (1989a)'s sixth step of Shaping Hypotheses can be subsumed under Wynn and Williams (2012)'s principle of Retroduction: the central analytical step in which the causal mechanisms (which are epistemologically similar to hypotheses) are identified and described. Finally, Eisenhardt (1989a)'s seventh and eighth steps can be subsumed under Wynn and Williams (2012)'s principle of Empirical Corroboration: rigorously comparing the mechanisms with the case evidence, as well as existing theoretical knowledge about the phenomenon under investigation, in order to ensure that the identified

mechanisms provide the best available explanation of the cases. Wynn and Williams (2012)'s fifth principle – Triangulation and Multimethods – can be applied at all steps of the project, and will be, in this study.

The integrated model is summarized in table 3 below.

**Table 3: Integration of Eisenhardt with Wynn and Williams**

<b>Integration of the Methods</b>	
<ul style="list-style-type: none"> <li>• <b>Explication of Events</b> <ul style="list-style-type: none"> <li>○ <i>Getting Started</i></li> <li>○ <i>Selecting Cases</i></li> <li>○ <i>Crafting Instruments and Protocols</i></li> <li>○ <i>Entering the Field</i></li> <li>○ <i>Analyzing Data I: within-case analysis</i></li> </ul> </li> </ul>	Triangulation and Multimethods
<ul style="list-style-type: none"> <li>• <b>Explication of Structure and Context</b> <ul style="list-style-type: none"> <li>○ <i>Analyzing Data II: cross-case analysis</i></li> </ul> </li> </ul>	
<ul style="list-style-type: none"> <li>• <b>Retroduction</b> <ul style="list-style-type: none"> <li>○ <i>Shaping Hypotheses</i></li> </ul> </li> </ul>	
<ul style="list-style-type: none"> <li>• <b>Empirical Corroboration</b> <ul style="list-style-type: none"> <li>○ <i>Enfolding Literature</i></li> <li>○ <i>Reaching Closure</i></li> </ul> </li> </ul>	

One recommendation of both Eisenhardt (1989a) and Wynn and Williams (2012) that was *not* followed in this study is the recommendation that multiple investigators be involved in all aspects of the study. The recommendation that multiple perspectives and triangulation be applied has been followed. I have regularly consulted with my supervisors, and have conducted several presentations through the course of fieldwork and analysis to get feedback from colleagues and, in the later stages, partners in industry. However, because of the requirement that the work reported in this thesis be the candidate's, all data collection, all data analysis and all major intellectual contributions in this thesis are my own. This is a limitation of the study, one that is likely common to most doctoral research.

Wynn and Williams (2012) state that because critical realist case study research tends to focus on the specific structural entities involved in a given case, these studies will typically focus on a single, or limited context (Wynn & Williams, 2012, p. 804). This is an acceptable approach when the focus of the investigation – the thing to be explained – is the phenomenon that is observed. However, when the focus of the investigation is the *mechanisms themselves*, this strategy has obvious limitations. If a mechanism is observed in a single context, or observed to cause a single event, then the abductively derived

understanding of the (unobservable) mechanism will be limited to how it responds to the enabling, releasing and constraining conditions that were present that were present in that single context. A much richer picture of the mechanism and how it interacts with the environment would be gained if it were observed to operate in many dissimilar contexts. The arguments for the existence and operations of the mechanism would also be strengthened, which reflects the reasons why some case study methodologists tend to recommend the multi-case strategy (Eisenhardt, 1989a; Yin, 2009).

Fortunately, both Wynn and Williams (2012) and Hedström and Ylikoski (2010) suggest a solution to the problem of structural analysis in multi-case designs where mechanisms are being derived: the use of theoretical knowledge about the phenomena being investigated to parse the case data. This strategy will be used in this study, and its application will be described in the next chapter.

## 4.5 The New Design

A critical realist investigation of a phenomenon involves making observations in the domain of the empirical, in order to abductively derive the existence of mechanisms in the domain of the real, which explain those observations. Wynn and Williams (2012) state that the research questions in a critical realist study must therefore seek to answer the question “What properties must exist for [the phenomenon of interest] to exist and to be what [it] is?” They also cite Danermark et al. (2002, p. 97)’s formulation: “What makes [the phenomenon of interest] possible?”. Mingers (2004c, p. 92) states that we ask what the world must be like in order for the phenomenon of interest to have occurred. The researcher must ask what mechanisms – what configuration of structures, powers and tendencies – must exist, in order to account for observed reality.

For this study, having adopted a critical realist perspective, all earlier research questions were replaced with one single question:

What mechanisms must exist in order to account for the observed instances of the creative appropriation of information systems?

The new research question encapsulated the requirements for a critical realist explanation of the phenomenon of end user creativity. It required a description of the causal mechanisms that explain the phenomenon under investigation, that is, the creative appropriation of IT systems by end users. This question is primarily about *existence* – it requires that the researcher provide evidence that a mechanism or set of mechanisms exist, which explain the phenomenon. However, the question is also about *description*, it requires that the researcher describe the mechanisms and show how they can account for the instances of creative appropriation that have been observed. Those explanations must be contextually specific, each case is seen as a unique set of events and must be individually explained (Wynn & Williams, 2012, p. 804), but the mechanisms themselves must be universal, in that they seek to provide a general

explanation of the phenomenon of creative user appropriation. This suggests that the structural analysis (Wynn & Williams, 2012) which identifies the mechanisms and their component structures should look at structures which are common to all incidents of creative appropriation, rather than contextually specific to any single incident.

The identification of these mechanisms takes a particular form in critical realist research. It is not enough to simply identify that a mechanism is there, it must also be described. The description of a mechanism, according to Wynn and Williams (2012, p. 794) should include the conditions that encourage (enabling conditions), trigger (stimulus conditions) and remove impediments to (releasing conditions) the mechanisms, as well as showing how those conditions worked within the case context to cause the events that were observed. It must be restated for emphasis that critical realism assumes the social world to constitute an open system. The resulting multifinality and equifinality mean that the issue of generalizability takes on a specific meaning in critical realist research. Generalizing findings through statistical inference from a sample to a population is not an acceptable strategy for explanation in CR (Wynn & Williams, 2012), indeed, purely statistical explanations of phenomena are unacceptable in CR research (Tsoukas, 1989). Instead, descriptions of mechanisms must be comprehensive enough to explain how and why they led to an observed outcome, and, for example, how they might lead to a different outcome given a different set of conditions. The mechanisms must therefore demonstrate the kind of causal depth which supports sophisticated explanatory strategies, and are consistent with the observed evidence.

It should be noted, however, that the revised research question at this point does not specify what type of mechanism must exist in order to explain the instances of creative appropriation. At this point in the study, the nature of the mechanisms had not yet been defined.

In the following section, I will describe the analytical plan that was followed in order to identify and describe the mechanisms that are causally relevant in incidents of creative appropriation.

## **4.6 Analytical Plan**

Like the philosophical assumptions being applied in the project, the analytical plan being followed in this research evolved over the course of the study. Initially, it involved a strategy of iteratively accumulating evidence in the form of propositional statements, following the strategies outlined by Eisenhardt (1989a), and testing those statements following the logic of A. S. Lee and Hubona (2009). For the reasons outlined above, the analytical plan of the study was adjusted.

The actual plan which was finally adopted comprises seven steps, some of which are iterative. They are:

1. First cycle coding of the case data using *a priori* constructs

2. Construct narrative networks
3. Code the narrative networks using AFT
4. Retroductive Analysis
5. Second cycle coding of the case data using mechanisms
6. Construct framework matrices
7. Describe the mechanisms using the aggregated evidence

These steps fit into the framework for conducting critical realist research as per Wynn and Williams (2012). Each is described below.

#### **4.6.1 First Cycle Coding**

For each case, all available data, of whatever type, was collected, in keeping with the principles of Eisenhardt (1989a) and Yin (2009). However, in each non-negative case, the primary data source was semi-structured interviews utilizing the Critical Decision Method (G. A. Klein et al., 1989) instrument. These interviews were transcribed, and the transcript, along with an audio file of the actual interview, was imported into the NVivo 10 qualitative data analysis program. Also, if any of the supplementary data collected for the case was in a format that could be imported into NVivo (e.g., documentation files, presentations), I did so. For data sources which could not be imported (e.g., personal observations, software samples), I composed field notes, which were imported into NVivo.

First cycle coding (Saldaña, 2009) of all the case data in NVivo was then carried out using the a priori constructs from (Amabile, 1996).

#### **4.6.2 Construct Narrative Networks**

The case data was then systematically reduced to narrative networks, following the principles of Pentland and Feldman (2007). Narrative networks are an analytical technique developed to identify and clarify the key story – the narrative – concealed in complex and voluminous case data. They isolate and describe the “series of events that make up the core story” (Pentland & Feldman, 2007, p. 782). Narrative networks are a versatile tool and can be used in many ways (Constantinides & Barrett, 2012; Goh, Gao, & Agarwal, 2011; Yeow & Faraj, 2011). In this study, they are being used to reduce the data (Miles & Huberman, 1999), and to isolate the key events that are part of the incidents of end user creativity.

A more thorough explanation of narrative networks is included below.

The construction of the narrative networks is a deeply analytical process. There are a large number of events involved in each case, but a relatively small number make up the “core”. The analysis of the overall case and teasing out of which events are key to the story constitute what Wynn and Williams (2012) call the “Explication of Events” principle.

### 4.6.3 Code the Narrative Networks using AFT

The first step in the process of analysis in both Eisenhardt (1989a) and Wynn and Williams (2012) is the description of the events in the cases. Description of events includes details of actions, specific structural components, and importantly, the sequence of events (Wynn & Williams, 2012, p. 798). The importance of sequence justifies the use of the Narrative Network, which explicates sequence well. Narrative networks are explained in more detail below. According to Wynn and Williams (2012, p. 797), empirically observed experiences in the case data must be theoretically abstracted for analysis. The abstraction process in this study is done using Affordance Field Theory (AFT) constructs.

AFT is a theoretical framework for describing the interaction between a (individual or collective) user and an IT system to perform a task (Burton-Jones & Straub, 2006) that has been developed as a part of this study. AFT provides a set of conceptual objects, relationships between those objects, and actions, which together allow an abstract description of the actions that occur as users search for, identify and enact ways of using systems. The discovery and application of these abstract concepts constitute what Wynn and Williams (2012) describe as the Explication of Structure and Context. The nodes of the narrative network (i.e., the core events) are critically redescribed from an actor's viewpoint into a theoretical perspective (Wynn & Williams, 2012, p. 796) by coding the nodes of the narrative network with AFT constructs.

The development of AFT is one of the major contributions of this thesis, and is described more fully in the next chapter.

### 4.6.4 Retroductive Analysis

Retroduction, the heart of a critical realist analysis, involves identifying the powers and tendencies of the identified structures that may have interacted to cause the observed events (Wynn & Williams, 2012). In other words, retroduction involves identifying and describing the mechanisms that are at the heart of the explanation developed in the study. This is done by asking a form of the question, “What mechanisms, *if they existed*, would account for the phenomenon to be explained?” (Mingers, 2004c; Wynn & Williams, 2012). The coding of the narrative networks using AFT means that it will be possible to theoretically abstract away the contextual details of each specific case, and compare the information processing operations being conducted at a structural level. Retroduction is an abductive logic, and has the same logical form as *retrodiction* (Wynn & Williams, 2012, p. 799). However, retroduction involves identifying new mechanisms, while *retrodiction* involves using previously identified mechanisms to explain new outcomes. The retroductive process, in this study, will be complete when retroductive logics are sufficient to describe all events in a given case. This will be discussed more fully in the section on closure.

Although retroduction is the central principle involved in a critical realist analysis (Wynn & Williams, 2012, p. 799), there is very little concrete guidance in the literature in term of specific steps, given the

intuitive and creative nature of the process (Wynn & Williams, 2012, p. 800). Retroductively deriving mechanisms is identical in logical structure to developing theory, a process for which there is precious little guidance in the published literature (Bourgeois III, 1979). Wynn and Williams recommend that a wide range of analytic approaches proposed by various authors working from various metatheoretical assumptions and methodological techniques be applied if helpful. In this study, I will apply the principles of theory construction proposed by Weick (1989). I will note the patterns of information processing that emerge from the case data, then conduct multiple thought trials (Weick, 1989, p. 522) to construct mechanisms which can explain those patterns. The underlying logic here is that when a mechanism is not perceptible, it can be identified, not by the ability be perceived, but an ability to do (Wynn & Williams, 2012, p. 794). We can infer its existence from the observable experiences that we believe it has caused. As a check on the sufficiency and comprehensiveness of the set of mechanisms identified in the retroductive analysis, the nodes of the narrative networks will be recoded using the mechanisms as codes. If all the necessary mechanisms have been identified, all the nodes of the narrative network for each case (i.e., all the core events in each incident of creative appropriation) should be codable using the set of identified mechanisms.

This step in the analysis will provide some *empirical corroboration* (Wynn & Williams, 2012) for the mechanisms, by demonstrating that they have the explanatory power to describe what is happening in each case. The mechanisms should be able to account for all the core events in each case.

#### **4.6.5 Second Cycle Coding**

Once a set of mechanisms has been identified and corroborated, the case data will undergo second cycle coding (Saldaña, 2009) using the mechanisms as codes. Each event that is analytically linked to the activation of a specific mechanism will be coded to that mechanism.

It should be noted at this point that there is an inevitable stochastic element to this part of the analysis. Multifinality and equifinality mean that there will almost inevitably be multiple *possible* explanations for some events. This is an inevitable feature of any critical realist analysis. Wynn and Williams (2012) advise that in such situations, researchers must compare and contrast alternate possible explanations, and select the one that has the strongest explanatory power: a process they define as *judgmental rationality* (Wynn & Williams, 2012, p. 795). As explained by K. D. Miller and Tsang (2011, p. 148): “Even if a particular mechanism is not directly observable, the more observable effects that logically are attributable to the mechanism, the more compelling the case for its presence.” Given the fact that the mechanisms to be identified are cognitive information-processing mechanisms which, like many mechanisms in the domain of the real, are largely unobservable, judgment rationality will be applied in this study.

The fact that, at some points in the analysis, it will be necessary to apply the researcher’s judgment to the question of which mechanism is active in a particular event is not as significant a limitation for this study

as it may appear on the surface. The goal of the study is to derive a set of mechanisms which can explain end user creativity in the appropriation process. The study aims to defend the *existence of the mechanisms*, rather than the facts of any specific case. I therefore submit that the most critical fact is whether or not the mechanisms *can* account for the observations in the case data.

#### **4.6.6 Construct Framework Matrices**

Narrative networks analyze the events which occur within a particular story, or narrative. They therefore serve the purpose of Eisenhardt (1989a)'s "within-case analysis" analytical step. However, a narrative network is a processual tool that is good at illuminating what effect a particular mechanism had on a particular event in a particular case, but is less optimal (given the way they are being constructed in this study) for cross-case analysis. To thematically analyze the effect of each mechanism across the cases, I will employ a tool developed by Ritchie and Spencer (2002), *Framework Matrices*. Since 2011, the Framework tools have been integrated into NVivo software. The second cycle coding of the data with the mechanisms will enable the automatic generation of framework matrices within NVivo from the case data. Further information on the Framework tools is given in a section below.

The framework matrices will provide a thematic analysis of the activation of each mechanism across the different cases. This will add insight into the nature of each mechanism, and help to determine what contextual conditions interact with it and how; leading to a more comprehensive explanation and description of the mechanisms. It should be emphasized that there is no assumption of symmetry between the coding of the narrative networks and the framework matrices. The narrative networks represent an analytical reduction of the case data, while the framework matrices are run from the mechanism-coded raw data. The expectation is not that the framework matrices will reflect the narrative networks, but that *each type of explanation will make sense*.

The logical forms of the narrative networks and the framework matrices – processual and thematic, respectively – are complementary, with each providing insights into a different aspect of the mechanisms. The two together provide further empirical corroboration of the set of mechanisms by demonstrating that they provide good explanations from either perspective. They also fulfill Wynn and Williams (2012)'s principle of *triangulation and multimethods*. By using multiple analytical and methodological techniques I increase the likelihood that the identified mechanisms represent the best possible explanation of the observed events.

#### **4.6.7 Describing the Mechanisms**

The evidence from the narrative networks and framework matrices will then be used to describe the mechanisms identified. The description of the mechanisms from the case evidence will be supplemented by descriptions of information processing mechanisms in the mind which conform to the patterns that the

mechanisms explain. Wynn and Williams (2012) provide guidelines on what elements are part of a description of a mechanism, and these will be followed.

## 4.7 Analytical Tools

In this section I will briefly discuss the most important analytical tools which will be applied in the study: narrative networks, and framework matrices.

### 4.7.1 Narrative Networks

Pentland and Feldman (2007) advocate the investigation of how technology is used in organizations by studying people going about their work, as they term it: “*people using tools to do tasks*” (emphasis theirs) ((Pentland & Feldman, 2007, p. 781). This conceptualization is symmetrical with the definition of system use by Burton-Jones and Straub (2006), as a “*user’s employment of one or more features of a system to perform a task*” (emphasis mine) (Burton-Jones & Straub, 2006, p. 231). This tripartite conceptualization of usage (of which appropriation is a type) suggests that each element must be examined in order to fully understand an incident of system utilization in context; a conclusion formalized in Burton-Jones and Straub (2006)’s concept of *rich measures* of usage.

A tool developed by Pentland and Feldman (2007) for examining this interaction of users (people) and systems (tools) and tasks is narrative networks (Pentland & Feldman, 2007). A narrative network is a way of making visible the actions that make up a particular interaction of the elements of using a system. The term “narrative” in narrative networks is not meant in the sense of “rich description of contextual information”, but rather on eliciting the set of events that make up the “core story” in a perhaps complex incident (Pentland & Feldman, 2007, p. 782). The philosophical assumptions behind narrative networks borrow from a number of theoretical perspectives. From *structuration theory*, Pentland and Feldman (2007) borrow the principle that what a technological artifact *is* is enacted — determined by what is done with it — rather than inherent (Giddens, 1984; Orlikowski, 2000). From *actor-network theory*, they borrow the principle of *translation* — a technology is not what its designers or implementers intend it to be, but what its users enact it as. They also borrow the principle that *actants* can be both human and non-human objects, and that those objects form *networks* which are defined by *associations* between actors (Latour, 1991). From the *theory of organizational routines*, they borrow the concept that the *tasks* for which IT systems are used tend to be embedded in organizational routines which define them, routines that have both *ostensive* and *performative* aspects. The ostensive aspects define the activity and provide a general script for the actions that constitute it. That is, they define the activity *in principle* (Latour, 1986). For example, “paying a phone bill online” could ostensibly involve: logging on to the phone company’s website; checking the amount owing; clicking the “Pay Now” button; entering credit card details; confirming payment. On the other hand, the performative aspects include concrete, specific details of each performance of the routine; performances which, while exemplars of the ostensive process, may be both

improvisational and unique. That is, they define the activity *in practice* (Latour, 1986). For example, “me paying *my* phone bill online” could performatively involve: logging on to the phone company’s website; checking the amount owing; disagreeing with the amount shown on the site; checking my phone’s call records; calling the customer service line; etc. They also borrow the concept that there may be many perspectives to any story of a series of events, based on the perspective of each actant (Feldman & Pentland, 2003).

A narrative network is constructed by first, choosing a point of view from which to tell the “story”. The researcher then collects data on the things that happened in the incident, and assembles them into *narrative fragments*. Narrative fragments are pieces of narrative, each relatively short (Pentland & Feldman, 2007, p. 788), describing a single event. Each narrative fragment answers the question: what happened? A narrative fragment consists of at least two actants, and some kind of action that occurs with or between them. Fragments are considered the *nodes* of the network. The final part of constructing the narrative network is to arrange the nodes in sequence. The final sequence (the fully-constructed narrative network) answers the initial question “what happened?” at the beginning of the network, then answers the question “what happened next?” at each subsequent node until the termination of the network. In this study, I will use the *researcher’s point of view*: synthesizing all the available collected evidence into the best possible account of what actually took place in each case. Narrative networks reflect model time rather than clock time.

Narrative networks are versatile tools, and have been used in a wide range of prior studies (Boos, Grote, & Lehtonen, 2009; Constantinides & Barrett, 2012; Hayes, Lee, & Dourish, 2011; Sammon, Nagle, & McAvoy, 2012; Yeow, 2009; Yeow & Faraj, 2011). They can be used to represent routines, potential actions, hypothetical actions, isolates (actions not connected to other nodes on the network), analyze frequencies of links, etc. (see Pentland & Feldman, 2007, pp. 791-792). In this project, not all the potential uses of the technique will be explored. The narrative networks constructed in this project will primarily be used as straightforward reductions of the case data. Multiple sources of data will be used to establish what happened and when, and this will be coded into narrative fragments, arranged by sequence, and compiled into a narrative network. However, there may be times when different data sources offer conflicting accounts of the same event. In such cases, the narrative network will be constructed to show branching possible events, and each will be analyzed and coded using AFT, then the mechanisms. The test will be, not the absolute truth of each account of the event (which may not be provable), but the ability of the mechanisms to construct a plausible explanation for each possible narrative of the event.

#### **4.7.2 Framework Matrices**

The data collected in this project will be managed in a case study database as recommended by (Yin, 2009). The case data will be managed in the NVivo software package and the project journals, interviews, and models generated during data collection, as well as any supplementary data or supporting

documentation that can be digitized, will be stored in the software. If hard copy documents or other physical artifacts are collected as part of the case data, they will be stored securely and records of them will be created in NVivo and stored in the case database using the guidelines proposed by Miles and Huberman (1999). All coding, transcription, modeling and analysis will be conducted in NVivo.

The features of NVivo that facilitate framework analysis will be used to support the empirical corroboration of the mechanisms. Framework analysis, developed at the UK National Center for Social Research (NatCen) by Ritchie and Spencer (2002), is a comprehensive methodology for analyzing qualitative data, designed for policy analysts. The entire framework analysis protocol will not be utilized, but a key tool within that protocol – what Ritchie and Spencer (2002) term “charting” – which is supported by NVivo, will be used to thematically reanalyze the case data using the software. Charting is a data reduction process in which two-dimensional charts are constructed in which cases are placed in rows and themes (called ‘indexes’ in Framework) are arranged in columns and matched to the cases. In framework methodology, summaries of the relationships between themes and cases are placed in each intersecting cell that is formed in the chart. The strength of using the tool in NVivo comes from the fact that the summaries of the effects of each mechanism in each case can be linked directly to the data in that case that is coded to the mechanism.

It should also be noted that while Ritchie and Spencer (2002) say little about the explicit philosophical orientation of the method, NatCen’s own internal training materials have identified the approach as “‘critical realist’, or ‘pragmatic’ ” (Wardle, 2011, p. 2). In this study, the mechanisms which have been identified using retroductive analysis of the narrative networks will be reanalyzed using framework matrices. The mechanisms will be used as themes, and summaries of the operation of the mechanism within each case will be placed in the intersection.

## **4.8 Enfolding Literature**

The mechanisms identified in the study are information-processing mechanisms that are part of human cognitive systems. There is a long tradition in cognitive science of modeling the operations of the mind as a set of information-processing mechanisms (Bechtel, 2008; Boden, 2004). This study extends that tradition by using the lens of distributed cognition to propose mechanisms that occur at the level of both individual and embodied distributed cognitive systems (Thagard, 2012). If these mechanisms truly exist, then there should be evidence of them in the extensive literature that exists on the operations of the mind, and those of the extended systems which form part of the distributed cognitive system. This does not mean that the retroductive analysis will be constrained by the structure of existing cognitive theories (see Weick, 1989, p. 516), but that the kinds of patterns that the mechanisms imply should to some extent be observable in the prior literature (K. D. Miller & Tsang, 2011). The reasoning follows the critical realist principle of Triangulation (Wynn & Williams, 2012).

This study will not attempt to “falsify” or “test” the mechanisms retroductively derived, apart from the empirical corroboration that is a part of the research design. However, to support the findings, and provide an additional source of evidence triangulation, examples from literatures such as those on creativity, cognitive science, the history of science, and philosophy, will be enfolded into the analysis, to strengthen the case for the explanation provided by the mechanisms.

## 4.9 Closure

Eisenhardt (1989a) notes that there are two important aspects to the issue of how to define the point of closure, when the study should be terminated. The first aspect is when to stop adding cases to the study: i.e., when to stop collecting data. Ideally, this should be done when *theoretical saturation* is reached. That is, when the marginal learning from each case becomes small, because what is being seen has been seen before. While Eisenhardt (1989a, p. 545) notes that pragmatic considerations (e.g., resource and time constraints) can influence this decision, the goal of theoretical saturation is the ideal, and will be aimed for in this study. The second aspect of closure is when to stop iterating between theory and data: i.e., when to stop data analysis. Again, the ideal is saturation, which is again described as the point at which the incremental improvement in the theory being developed is small. Of course, given the iterative nature of data collection and analysis in Eisenhardt (1989a)’s framework, these two aspects of closure are highly interconnected.

In this study, the question of how to define the point at which theoretical saturation is reached is addressed as follows. Since the goal of the study is to identify the set of mechanisms that explain creative appropriation in a general sense, rather than in a specific context, it will be important to verify that each mechanism identified is causally effective under different circumstances. The cases selected will therefore be theoretically replicated to ensure that each case context has distinct characteristics. Theoretical saturation for data collection will be defined as the point at which:

1. The set of mechanisms identified is sufficient to code each node of the narrative network in each case
2. Every mechanism has been observed to be effective in more than one case. That is, each mechanism is *corroborated*, in the sense of A. S. Lee and Hubona (2009)
3. Adding a new case does not result in the discovery of any new mechanisms, or result in a significant reformulation of already-identified mechanisms

For data analysis, theoretical saturation will be defined as the point at which I have satisfactorily shown that the hypothesized mechanisms sufficiently approximate reality. This point will be reached when the empirical corroboration of the identified mechanisms is complete. Wynn and Williams (2012) list criteria for evaluating casual explanations based on mechanisms from a realist perspective based on Runde

(1998), by applying rigorous empirical scrutiny to the findings. They are based on the following causal test questions:

- 1) Are the causal factors of the phenomenon actually manifest in the context?
- 2) If the causal factors were part of the context, were those factors causally effective?
- 3) Do the causal factors provide a satisfactory explanation to the intended audience?
- 4) Does the proposed mechanism provide causal depth?

When each of these questions has been addressed for *the set of mechanisms identified as a whole*, analytical saturation will be defined as having been reached.

## **4.10 Discussion**

A key benefit of the case study approach is the ability to make use of opportunities presented by the data. In this study, I will use complementary analytical techniques to pull apart the data in the explication of events, and the analysis of the structures in context, as recommended by Wynn and Williams (2012). I will do so in a way that is fully consistent with the Eisenhardt (1989a) framework. The combination of narrative networks and framework matrices addresses a specific problem identified in chapter 2 that is endemic to studies of appropriation in field contexts. Together they can capture the performative aspects of an ostensive series of events, making them a suitable set of lenses through which to look at creative appropriation in context. Together with the opportunistic use of replication logic (Yin, 2009) to find informative patterns in the data, the methodology above provides a solid foundation for the retroductive analysis that is central to this project.

It should also be noted that the mixing of processual and thematic logics in this study mirrors the approach of Eisenhardt in her studies of strategic decision-making (Bourgeois III & Eisenhardt, 1988b; Eisenhardt, 1989b; Eisenhardt & Bourgeois III, 1988). These were part of the foundation for the development of her theory-building roadmap and are cited several times in Eisenhardt (1989a).

Overall, the approach attempts to follow the advice of Easton (2000) to be both rigorous and creative, employing creativity to study creativity.

## **Chapter 5. Case Studies**

### **5.1 Introduction**

The data collected in the study was analyzed from two perspectives. There was a nomothetic holistic analysis of all the data, including natural experiments, negative cases, and overall observations. There was also an ideographic atomistic analysis of several selected cases. As a general rule, the atomistic analyses were used to identify and describe the mechanisms, while the holistic analyses contributed insight into how the mechanisms work together as a system. The atomistic analyses are based primarily on narrative accounts of incidents in which systems were creatively appropriated by users. As Leonardi (2011, p. 155) notes for reading chains of imbrications, the choice of a case boundary is largely arbitrary. A number of starting points could easily be argued for each case, it could be defined as when the main characters were trained, or when the background factors of the case came into being. The boundaries set in each of these cases was determined both by the researcher's judgment and the limitations of access to data in each case. This is a limitation of much real-world case research (Yin, 2009).

In this chapter I will follow Yin (2009)'s "fourth strategy" for reporting multiple-case studies by not attempting to completely describe each case, but rather defending the findings from abbreviated vignettes about what happened in different contexts (Yin, 2009, pp. 172-173). I will summarize the data collection exercise as a whole, then I will focus in on the cases, providing brief descriptions of each organization, and describing what happened that contributes to knowledge about the mechanisms. I will then briefly describe the procedure that was followed for measuring the "creativity" of the appropriation process in each case. I will then describe the initial observations and reasoning that led to the modification of the study to a critical realist perspective.

### **5.2 Summary of Data Collection**

The data described below was collected over the course of 14 months from May 2012 to July 2013. The data was collected in organizations in three cities across New Zealand. Participant organizations were identified through contacts in industry, as well as referrals from existing participants and colleagues in the Human Interface Technology (HIT) Lab, New Zealand. In each organization in which I collected data, the process began with the identification of, and initial meetings with, a participant within the organization who served as main informant. In some cases, such as the organization called Alpha below, the approval of the main informant (the CEO) was sufficient to gain access to the organization. In other cases, such as the organization called Eta below — a medical device manufacturer — collecting data required me to be cleared for access to sensitive internal information, and approval had to be gained from the company's parent company overseas before I was able to collect data.

In each organization I sought to identify incidents in which end users had appropriated an IT system in a way which could potentially be rated as creative. When such incidents were identified, I then checked to see if the criteria for case selection outlined in the section “Case Selection and Protocols” was fulfilled in terms of the data that was available, and whether the case was an appropriate theoretical replication — i.e., was sufficiently dissimilar from previous cases to promise to give relevant additional information. In the four organizations where such cases were found, I followed the procedure outlined in the case study protocol. Not all cases of which I became aware were included in the study. For example, in one company I was told of a case of creative appropriation that was interesting, but which could not be further investigated without putting participants at risk (an internal system had been used in a legal, but officially unsanctioned, manner). This case, and the company, were therefore dropped from the study.

In two organizations, I found conditions that classical theories of creativity would suggest were highly conducive to creative action, but where no creative appropriation had occurred. This was very interesting in light of the open question about whether the determinants of creative appropriation were somehow different from those where creative action was an explicit goal of the creative actor. I dubbed these organizations “negative case” organizations, and collected data that I thought was relevant in them. In the “negative case” organizations I followed a similar procedure to the case study protocol, but replaced the Critical Decision Method (CDM) semi-structured interview protocol with an unstructured exploratory interview protocol.

In two of the organizations in which I collected data, I did not collect data on specific individual cases, but rather observed organization-level trends that gave insight about the nature of the determinants of creative appropriation, and contributed to the theory that was developed. Following Yin (2009), I used replication logic in each of these cases, treating them as natural experiments that gave insights into the nature of the appropriation process. I describe those organizations and the data I got from them in the section “Natural Experiments” below.

Finally, once the theory described in the later chapters of the thesis had been developed, it had to be compared to reality to see if it could generate plausible explanations for real-world events in other contexts. I went into two organizations in which making sense of user appropriation behaviors is an intrinsic part of their regular operations. One is a technology consultancy that specializes in developing custom bespoke IT-based system solutions for industry clients. The other is a penetration-testing firm, which tests and certifies the security of websites that handle confidential data by running simulated hacking attacks against those sites. I conducted confirmatory unstructured interviews with experts from each company as part of the Empirical Corroboration phase of the project.

In all I conducted data collection in ten organizations concerning 18 cases in which IT systems were appropriated in ways that were novel, useful, and new to the users who were involved in the appropriation process. Five of those 18 cases were investigated in depth using the CDM technique. I conducted 49

formal interviews, and had a large number of informal conversations and interactions with staff in the participant organizations. In addition, I collected documentation, archival records, made direct observations and collected physical artifacts, to collect as many types of data as were available on each case (Yin, 2009). In addition to interviews and collection of archival data, I also conducted discussions with industry experts, and conducted meetings and workshops with innovation specialists and engineers from industry. The cases for which I conducted CDM interviews were rated for creativity using a procedure based on (Amabile, 1982, 1996)'s Consensual Assessment Technique (CAT). I conducted five rating interviews, including pilot and test interviews, which will be described in the next section.

### **5.3 Measuring Creativity in the Cases**

Creativity researchers have been accused of not knowing what they are talking about, according to Amabile (1996, p. 19). That is a somewhat tongue-in-cheek characterization of a serious issue for creativity researchers: the “criterion problem” (Amabile, 1982, 1983; Batey & Furnham, 2006). In order for studies of creativity to establish content validity, they must confirm that what they are studying is, in fact, “creative”. While there are many ways of defining “creativity”, there has to be an underlying consensus on the meaning of the term in order for studies to measure a common thing (see Csikszentmihalyi, 1997, p. 24). The current consensus in studies of creativity has tended toward treating creativity as a matter of consensus among suitable raters about the “creativity” of a product. The most commonly-applied technique for performing this measurement is the Consensual Assessment Technique (CAT) (Hennessey & Amabile, 1998; R.K. Sawyer, 2012), commonly attributed to Amabile (1982), although R.K. Sawyer (2012) credits Csikszentmihalyi (1965) with the first usage.

The CAT is one of the most widely accepted methods of measuring creativity in research. It involves the independent assessment of the creative product by appropriate raters. Appropriate raters are individuals who are familiar with the domain in which the creative product is produced. There is conflicting evidence on whether judges need to be expert in the domain, but they do need to be familiar enough to know the rules of the domain (Amabile, 1996). The measurement method employed in this study was based on the CAT.

In order to measure the creativity of the specific appropriation incidents that were chosen for the study, anonymized descriptions of the events and contexts involved was necessary. Constructing these descriptions presented unique challenges. The descriptions had to be detailed enough to allow a rater to judge the level of creativity that the incident represented. However, they could not be so detailed as to compromise participant anonymity, or to give away participants' intellectual property. The descriptions were constructed and printed on single-sided paper sheets. The ratings were done in interviews in which each rater was presented with one sheet at a time to assess. Raters were asked to use their own definition of what was “creative”, as in Amabile and Grysiewicz (1987). In conformance with the CAT, the order in

which the sheets were presented in each interview was determined by a random sorting algorithm, so that presentation order did not bias the data. Also, every rater had to be shown the exact same sheet for each case. While the rating exercise was being conducted, raters were invited to ask any questions for additional details they thought were necessary to make their judgments. Afterward, they were asked to explain the criteria they had used to make their judgments in each case.

Three major issues emerged during the conduct of this exercise. The first was that critical facts about the cases, which were relevant to the rating of the “creativity” of the individuals involved in the case, almost invariably emerged after data collection was started. To address this issue, I decided that each case would be rated only after all its data had been collected and analyzed. Only the five cases that were fully analyzed (i.e., had full CDM interviews done with participants and had narrative networks and framework matrices constructed), were part of the final rating exercise.

The second issue was that the domain which the raters had to be familiar with is not well defined. In a study of creative pianists, for example, it would be simple to define the kind of expertise that is relevant to judging their output. However there are a wide range of activities which can be said to fall into the category of “appropriating IT systems”. This created a challenge in terms of identifying the specific expertise that was required by raters. For example, in an early trial, one rater — a highly trained postdoctoral computer science researcher — was unable to draw on any frame of reference beside himself and his research colleagues for assessing what was creative. This made his rating criteria inappropriate for cases involving users who were not computer scientists.

In the final analysis, I used three highly experienced expert raters (J. C. Kaufman, Baer, & Cole, 2009) who shared the following characteristics:

- Long experience
- Experience in field or industry settings
- Broad range of experience
- Not otherwise involved in the project

The third issue had to do with what details should be in the case descriptions. For example, in one trial, a rater made a judgment explicitly based on the fact that he knew that a certain type of software was commonly used in certain way. This revealed that the date when the incident he was rating occurred (20 years before, when that type of software had just been introduced), was a relevant detail. The case description therefore had to be expanded to include the date. Because each rater had to receive the exact same description to rate, this meant that the exercise had to be started over.

In the end, the five cases that had narrative networks created for them were all rated as creative by at least two independent raters. The raters chosen were all experts in computer technology who also had extensive

experience and expertise in working with end users. Each rater came from a different professional background: one was a software developer, one an industry consultant, and one an IT support professional. No rater rated all five cases as “creative” and interesting differences in the criteria that were applied by different raters emerged during discussions. However, each of the five cases was rated creative by at least two of the raters.

The divergent criteria applied to cases by raters from different backgrounds proved interesting and, in some cases, unexpected. It suggests that this would be a fruitful area for future work. However, it is outside the scope of the present study.

## 5.4 The Case Data

In the following sections I will briefly describe the participant organizations in which I collected data. I will describe the organization, and what it does; who my informants within the organization were; what happened in each organization and, where relevant, what happened in the case(s) of creative appropriation that occurred within them.

The organizations are sorted into categories by the kind of data that I collected in each.

- In the *Creative Incident Cases* section are the organizations in which I conducted full CDM interviews, then constructed narrative networks and framework matrices to describe the data. Analysis of data from these cases led to the identification of the mechanisms that form the core of the findings reported for this study
- In the *Negative Cases* section I list the organizations in which no cases of creative appropriation were found, despite the existence of conditions that seemed to be conducive to it occurring. Analyzing what was happening in these organizations helped to shape my retroductive analysis. The mechanisms I have identified can explain why no creative appropriation happened in these organizations.
- In the *Natural Experiments* section are two organizations in which analyzing developments at the collective level using replication logic added important insights about creative appropriation. This helped to shape the retroductive analysis.
- In the *Corroborative Interviews* section I describe two organizations which have the development of use cases and the analysis of user appropriation behaviors at the core of their business processes. One is a system development firm, the other a security consultancy. As part of my empirical corroboration exercise, I interviewed the CEO/founder at one, and a consultant at the other. The feedback I got in each was consistent with what I expected from the findings from the analysis.

### **5.4.1 Creative Incident Cases**

These are the firms in which I performed primary data collection, and which provided the data for the narrative networks and framework matrices. In each of these firms, I had one primary informant who gave me access and enabled me to collect data within the organization.

A brief description of the firm, the case (in one firm, cases), and the context is provided below.

#### **5.4.1.1 Zeta**

Zeta is a large university in the South Island of New Zealand. It was established approximately 200 years ago and has close to 1,000 staff and 20,000 registered students. Zeta offers undergraduate and postgraduate courses in a wide variety of disciplines. Many of the courses taught at Zeta have an integrated Information Technology component. However, the use of IT at Zeta is also integrated into the administration of the institution. For example, all registered students receive a login account that can be used to access online library resources, pay for printing and scanning, and access other services. This account is synchronized across all the university services that can be accessed over the internet. My principal informant was a university lecturer in the Computer Science department who I will identify as RF.

Zeta's Learning Management System (LMS) is an adaptation of the open-source Moodle learning management application. Moodle has been integrated into the teaching and evaluation activities of many courses at the university and it is one of the official sources of information at the institution. All students at Zeta are required to have globally unique log-ins which are tied to the Moodle system through the university's LDAP directory. For its purposes, Zeta has installed and configured Moodle on its web servers, and has named its LMS to conform to the university's legal branding requirements. Because replicating the university's branded name for the LMS would compromise the anonymity of the institution, in this document the implemented LMS at Zeta will be identified as "Socrates".

Ever since his arrival at Zeta in 2004, RF had been frustrated by the limitations of the LMS system's testing abilities. Because of the number of students, it was not practical to give them constant individual feedback on each of their projects, so automated testing was necessary to reinforce learning as well as to assign partial grades for the course. There were three major ways in which grades were assigned during the course: a final examination, a major project, and in-course quizzes. The exam was not useful for learning purposes since it occurred at the end of the term. There was an 'autotester' system so that students could submit partial work for the major project and get feedback on how well it was being done. However, the autotester ran as a nightly batch job every 24 hours. That meant that the students could receive feedback on their work only once per day. RF was unsatisfied with the version of the autotester that was there when he arrived, and wrote a new version that improved on it.

The most regular source of feedback that the students got was in the short quizzes which were given to reinforce what was taught in lectures. Students who took these quizzes got immediate feedback on whether their answers were correct. However, the kinds of questions that Moodle allowed instructors to write did not let the students practice writing code - which RF felt was absolutely necessary for learning. Workarounds which allowed students to work with code were very demanding, and still did not allow for the crafting of the kinds of questions he wanted.

RF spent years making incremental improvements in the LMS-based system, trying to design different ways to develop and test the skills he wanted to enhance in his students. In 2009, he first encountered a website that allowed users to practice coding by writing small programs to accomplish tasks on the site. He recognized that it provided the kind of functionality that he wanted in his quizzes, but it was not, by itself, useful for his courses. After thinking through the challenges and the desired functionality over the course of several months, he wrote a module for testing blocks of Python code that he called “PythonCode” (name changed). This module was deployed and tested on a Moodle development server. After PythonCode was found to be functioning properly, the lecturer contacted the university’s IT support team to get it deployed on Zeta’s main Moodle server. A difficulty arose because the version of Moodle deployed on the main servers did not support functions that were needed by PythonCode. This was resolved by deciding to let the students in RF’s class log in to the development server. A long collaborative process between RF and several staff members in the IT department ensued to get the module working properly with the university’s environment and to provision the development server so that it could handle the load imposed by RF’s class. IT renamed the module to “PySoc” (name changed) to match Zeta’s LMS naming convention.

After the initial technical problems were dealt with, PySoc became a very useful and highly-regarded teaching tool that is well spoken of by all the lecturers and tutors who use it. A colleague of RF’s who also teaches the same class and has taught Python in the department before and after the implementation of PySoc, described it as “infinitely better” teaching with the module. Letting the students write code to answer questions “makes more sense” and makes it easier for them to get the concepts being taught.

#### **5.4.1.2 Beta**

Beta is a manufacturing company that operates in a number of countries, including Australia, New Zealand and China. In NZ, their main activity involves designing, taking orders from customers for, and planning and coordinating the manufacture and shipment of their main product. To protect the intellectual property of the company, the product that they manufacture will be identified in this thesis as “widgets”. All manufacturing of widgets is currently done at a factory in China. My principal informant was the IT manager of the company, who I will call MC.

Beta has been in business for over 40 years and was started by a pair of business partners who still run the company. Throughout that time its principal business activity has been the design and manufacture of widgets. It does not sell widgets directly to the public, but to resellers who stock them in retail outlets. Originally, the design of widgets was done using an electronic device designed for the purpose — Plotter — and the company’s manufacturing operations were carried out at a factory in NZ by staff who had been trained to work with Plotter. However, when demand increased, it became necessary to outsource some of the manufacturing operations, and the company entered into a business relationship with a factory in China. The factory was not familiar with Plotter, and so a special set of documents was designed to give the factory instructions on how each widget should be built and which materials should be used for each part. The unit costs of building a widget were much lower at the China factory, and eventually all widget production was moved overseas.

About 20 years ago, a crisis occurred at Beta because of a rapid increase in the volume of business. Different “lines” of widgets have specific designs and specifications. The specification documents for each shipment of widgets were sent to China by fax. However, with the large numbers of shipments, version control problems began developing, and shipments would arrive from China that had outdated or incorrect specifications. When this happened, there would be disputes with the factory about what instructions had been sent and when, making it difficult to determine who was responsible for the spoiled shipments. Communicating with the factory by fax became unwieldy and unsustainable.

In the New Zealand widget industry, access to personal computers and the internet was rare at that time, but Beta acquired a PC and an internet account for testing purposes. The supervisor of the production department — who I will call KT — had a discussion with her manager about the losses, both in terms of time and money, because of the problems that were developing with the factory. KT then had a discussion with JG, a member of her staff in the department who had been “playing around” with the computer. One of the software packages that was on the computer was an office productivity application that I will identify as Product. JG used some features of Product to develop an electronic representation of the information that was included in Beta’s specification sheets that were sent to the factory. JG, along with KT and her manager, refined the Product document so that it could substitute for the physical document that was then being faxed to the factory. The files from the productivity application could be sent via email to the factory, and the emails provided an automatic way of time stamping each set of documents.

Over time, the production team became increasingly familiar with Product. Also, the feature set of Product grew as it was regularly updated by the software company that produced it. As a result, much more sophisticated procedures such as the graphical representations of design elements and automated quality control steps were built into the software-mediated communications with the factory. MC, the current IT manager at Beta, expresses surprise that the production department continues to use Product, since specialized software tools that are designed specifically for designing widgets exist in the market. He has

got them to try several of these packages to see if they prefer them to working in Product, however the production team rejected them all.

The production department feels that the Product process they developed is optimal for the collaborative and iterative design process they employ. The specialized packages were focused on the initial design process, but did not allow them to modify designs or work with other stakeholders in the way that Product does. Also, in the widget industry, certain design elements are key differentiators for particular brands. Product allows them to modify previously-designed widgets in order to develop their new lines, which saves time and effort, while enabling them to retain the unique design signatures of their own brands of widget. The Product system is now intrinsic to the design process for Beta widgets, and is a critical part of their business. Product, it should be noted, is an office productivity system originally designed to be used for functions such as budgeting and inventory management.

Several years after the initial development of the Product system, the founders of Beta decided that the company had outgrown their own style of leadership, and needed professional management. They hired a team of professional managers which included a CEO, and an IT manager, who I will call RR. The hiring of the new executives was part of an effort by the founders to formalize their internal processes and increase efficiency, since rapid growth in their order volumes was making a number of business processes more difficult to manage. One particularly difficult process was communicating with customers about what types of widgets they wanted to buy, and in what quantities. Beta would receive relatively small orders for each line of widgets from each customer. When the orders were collated, they would then decide which lines of widgets could be economically manufactured, given the total number of orders. Several lines would typically be dropped at that point in the process, and the prices of some lines would have to be adjusted in order to make them profitable. The adjusted catalogue would then go out again to customers to enable them to make necessary changes to their orders based on the adjustments that had been made.

All the communication necessary to manage this process had traditionally been done using a large, printed order book, copies of which were physically distributed to the customers. As the volume of orders increased, this system became increasingly untenable. Small errors, such as differences between the product codes in the order book and those in the company's internal inventory management system, would mean time-consuming delays and frustrated orders by customers. In addition to the inefficiencies created by errors, the sheer volume of work required to run the manual system was making it impossible meet production deadlines. The merchandise manager, who I will call AN, discussed the situation with the new IT manager, RR. AN and RR agreed that there was a need to improve the efficiency of the ordering process, while maintaining the configurability and verifiability of the manual process. RR had several meetings with the marketing and customer relations staff, then went away to develop a solution.

RR designed a system which automated the ordering process using an electronic file generated by Product. The information that had previously been sent to customers in the paper order book was transferred into Product, and was sent to customers via email. Email made it easier to manage the communications with customers, and the files from these orders were returned to the IT manager after they had been filled out by customers. Information from their finalized order files (in Product) was then typed into Beta's ERP package for order processing. The IT manager became deeply involved in each step of the ordering process. The production of the electronic file with the order options for widgets was done by RR, who was also responsible for uploading the finalized order files to the ERP.

A few years after this system had been put into effect, the IT manager that had replaced the paper order book with a Product file resigned, and MC – the current IT manager – was hired to take her place. MC was highly dissatisfied with the large amount of manual processing that was involved in the processing of customer orders. MC had significant experience as a software engineer, and spent the first three weeks on the job automating the process of creating the Product order book. His initial goal was to reduce errors: the (then) current system made it possible to type in combinations of options for widgets that were not actually available, and a lot of time was spent dealing with data entry errors on the part of Beta and/or its customers. He also wished to move responsibility for the ordering process to the sales department, which was formally responsible for it. He then designed an intermediary system which would automatically “scrape” order configurations from the completed Product order files and load them into the ERP. He also designed automated reports that enabled the sales department to accomplish much of the checking and verification that had previously been done by RR. This arrangement makes his involvement in the actual ordering process minimal.

This researcher noticed an apparent similarity in the solutions that were developed for both the spec sheet and order book processes. Both were triggered by similar pressures being placed on a largely manual system. Both were similar in concept: convert the manual files to electronic files that were more versatile, and could be sent via email for automatic time stamping. Further, both used the same software application (Product), and both solutions had other underlying similarities that the researcher noticed when looking at the actual files. However, in approximately six hours of interviews as well as numerous informal discussions with several persons who had been part of the events, not one of the participants from Beta showed an awareness of the similarities between the two solutions.

### **5.4.1.3 Alpha**

Alpha is an independent information and knowledge management consultancy, based in a major city in New Zealand. The company develops solutions for complex challenges for institutional and government clients. It was started by a consultant with a PhD in atomic physics who had worked in a number of varied roles before starting the company. Alpha engages in consulting projects that sometimes require coordination from three or four government agencies at the same time. Alpha presents its solutions to

clients in the form of a consultancy report. This report — which takes the form of a bound book — is presented to the client at the end of the engagement, but the materials that make up the final report are developed iteratively over time, and often through a consultative process that involves various stakeholders in the multiple agencies. My informant was the founder-president of the company, who I will call JS.

In the late nineties, Alpha used a particular desktop publishing package — hereafter called *Desktop* — to produce the final printed report. Support for the Macintosh version of the Desktop product was dropped by the software publisher that distributed it, after Apple converted their operating system to a new Unix-based core. The publisher told their customers to move to Microsoft Windows. Alpha refused to change platforms, and so was forced to find a new way to produce their published reports. Alpha conducted a structured search of all the available desktop publishing solutions then on the market, but could not find another package that met their needs. At the same time that this was happening, Alpha began to use *wikis* — online collaborative webpages — to collaboratively develop project documents with their clients.

Alpha decided to build its own typesetting engine for converting web documents into structured documents that are suitable for printing. They started work but soon found that they were having problems with some steps in the process. They went to a nearby university for advice. While they were in talks with the university, DL, a computer science student who had been working with a formatting language for text, heard about the problem. He hacked together a basic prototype of a system for converting wiki pages into publication-quality output by piping the HTML code through scripts written in the formatting language he was working with. Alpha applied for and received money from a government fund for innovation research, which they used to hire DL part-time, giving him three months to produce a proof-of-concept system that could meet the requirements of the organization.

While the system was being developed, the team at Alpha discovered a number of other related projects on the internet which had been released as open-source projects. Code from these open source projects was integrated into the system that the student was developing. The proof of concept system — hereafter called *Publish* — was completed and worked satisfactorily, producing publication-quality reports that were suitable for distribution. *Publish* was put into service in Alpha, and was also released to the public as an open-source, publicly available resource on the internet.

*Publish* became unexpectedly popular. A number of organizations who wanted specially formatted documents began to get in touch with Alpha and ask them to make modifications to *Publish* so that it could handle their special requests. These included a global community that was producing recipe books from different countries, a university that wanted their students' computer science web projects converted to a format that could be bound with a thesis, and a number of other projects involving converting wiki-style web pages into formatted print outputs. The *Publish* system evolved as it was modified to meet each of those requests.

After Publish had evolved into a “highly capable system” as a result of being extended to meet different specific needs, JS was introduced to a developer, who I will call HG. HG was trying to develop an online platform that could enable a writer to write a book on a popular online blogging platform, which I will call Blog, press a button, and get output formatted as an e-book, or press another button and get a print version that can be delivered to an on-demand printer. According to JS, it typically takes 12 months from the time an author delivers a manuscript to a publisher to the time that the published book is in her hands, and an additional six months for the e-book. HG had built a system, but it was lacking several necessary features. The two of them decided to work together and it turned out that Publish had most of the features that HG’s system lacked. They worked together for a few weeks and were able to demonstrate the combined system — which they have named PubBooks (name changed) — at a major publishing conference. Their system has the potential to turn a process which currently takes over a year into one which takes several hours.

JS describes the set of accomplishments which led to PubBooks this way:

*“... So I think this is really quite exciting about where this kind of technology ought to be going. So I kind of think that the stuff that we’ve done was - we stood on the shoulders of giants, right? We actually didn’t do very much in the project because we took a whole bunch of existing components, we tweaked them and then we put a little wrapper across the top that made these previously disparate components able to talk to one another, to produce something new and useful for us. And it turned out that a bunch of other people were able to do something new and useful for them, and then this other project over here using another set of components was able to pick up and build on top of what we’ve done.*

*So I kind of see that we’re just a little stepping stone in this and so we’ve relied on giants and I think what HG’s doing with [PubBooks] is really interesting. So we’ve kind of made this little bridge that’s allowed one set of giants to communicate to the next set of giants. Because of course, he was building on what the [Blog] guys had done and what the e-pub people had done. And I think that’s what this is all about: you break out of these monolithic software silos and say “Well, there are actually a whole lot of software components that in and of themselves do useful things.” Wikis are useful, [the formatting language] is useful, [Blog] is useful, but when you can connect them up, and they’re all built to be connected, then you can start to do things that were never possible before.”*

#### **5.4.1.4 Gamma**

Gamma is a relief organization that specializes in deploying teams to disaster zones to offer medical support, distribute aid and supplies, mount rescue efforts and coordinate with local governments and

other disaster relief organizations in the aftermath of major disasters around the world. In order to accomplish these goals, emergency telecommunications and IT capabilities are essential. There are a number of response teams in the world that maintain trained personnel and equipment to deploy emergency ICT capabilities to disaster zones, and one of them is based in a city in the North Island, New Zealand. My informant was the senior manager responsible for international disaster response, who I will refer to as MP.

In order to make emergency deployments on short notice practical, it is necessary to use equipment which is capable of running familiar tools for managing communications, processing data and performing simple tasks which are necessary in the disaster zone, without requiring extensive training or imposing a steep learning curve on responders. Standard equipment for deployments include pre-configured laptops, handheld two-way radios, satellite phones, and VHF base transmitters. A significant amount of the work that needs to be done in a disaster zone is administrative: making resource requests, filing reports, etc. The IT and communications infrastructure is crucial to the successful managing of the logistic challenges of disaster relief. However, there are several challenges that come with each of the commonly-deployed systems, some of which are listed in Table 4:

**Table 4: Typically-deployed Equipment for Response Teams**

<b>Equipment</b>	<b>Challenge</b>
Laptops	Significant power requirements. Spend unnecessary time downloading updates over the limited (and expensive) available bandwidth. Take too long to set up.
Two-way radios	Expensive. Personnel need to be trained in proper radio procedure. Voice communication can encourage ‘thinking while talking’ which wastes time
Satellite phones	Very expensive. Useless indoors or in places where there is no clear line-of-sight to the sky, so not reliable in some circumstances.
VHF equipment	High power requirements. Can take a long time to set up. Can be very difficult to get through customs. Use of spectrum varies by country and equipment needs to be configured for each site.

Because of these challenges, there had long been some pressure to deploy mobile phones to disaster zones. Mobile phones are a familiar technology for most users in many parts of the world. They are extremely cost-effective, can contain cameras and GPS units, and have a significant amount of computing

power. However, mobile phones have a significant weakness: without a working communications infrastructure, they become single-user PDAs. The kinds of disasters that Gamma response teams are deployed to often involve interruptions in telecommunications services.

MP and a team of both professional (as in, employed to Gamma) and volunteer experts, over the course of several months, have developed a way of combining several different IT systems in order to deploy mobile phones usefully in areas where there is no working telecommunications infrastructure. The system, which he has named 'Mobile Data' (name changed), is comprised of the following components:

- *Android Cell Phones* – the system will work with any standard Android phone
- *The Mesh project* – The Mesh project (name changed) is run out of a university in Australia, and is essentially a software system that enables Android phones to form a mesh network among themselves. This means that, in the absence of a working cellular network, the phones will talk directly to each other. If a message is sent from one node of the network to another that is not in range, the nodes (phones) will use each other to 'hop' the message from node to node, until the message reaches its intended destination. The project also implements a store-and-forward capability: when a message exists and there is no forwarding node within range, the message will wait until another node (phone) comes within range. The message will then hop onto that phone and keep propagating across nodes (much like a virus) until it reaches the destination node.
- The *Tracker* tracking beacon – Tracker (name changed) is a small device, roughly the size of a pack of cigarettes. It was developed by a company in North America as a safety device for tracking and sending distress signals for hikers, mountaineers, and persons who may be outside of the reach of telecommunications infrastructure. It is designed to send distress signals via satellite uplinks. However it is also capable of sending simple text messages along with a tracking signal. It communicates with satellites and needs a line-of-sight to the sky to operate.
- *Forms* – Forms (name changed) is an electronic forms and data fusion platform developed by a company in North America.

The Mobile Data system brings the various parts together as follows. The Mesh and Forms software is installed on Android cell phones which are distributed to volunteers within the disaster zone. Volunteers fill out electronic forms to make reports, etc. The data captured by these forms is propagated over the mesh network to other nearby phones, each of which acts as a node on the network. The store-and-forward capability of the software means that this can be done seamlessly even when there are no available nodes nearby. Whenever other phones are nearby, data automatically propagates to them. This propagation continues until a phone which is within range of a Tracker unit gets the message. The Tracker unit sends the message, along with sundry data such as the coordinates from which the message was sent (using the text messaging facility) to a back-end server, using satellite transmission.

This means that data collection can be done automatically by sending Mesh-enabled phone through a disaster area until one of the phones comes within the range of a Tracker unit that has line-of-sight to a satellite. At that point, the data will be propagated to any location in the world where it can be collated into useful information. This system eliminates several disadvantages of the traditional IT systems usually deployed to disaster zones.

- The devices are familiar to most users and require less training and support than traditional laptops
- The entire system takes far less time to set up than traditional systems
- The mobile phones are extremely cost-effective and contain useful ancillary features (camera, GPS, accelerometers, etc.)
- An entire 'base station' (mobile phone and Tracker unit) can fit in a pocket
- The use of electronic forms structures the data-entry process and ensures comprehensive reporting while reducing air time lost to 'thinking while talking'.
- The store and forward capability means that it is not necessary for personnel to remain outside to stay in contact, as is necessary with Satellite Phones
- The equipment is typically familiar to customs in most countries and will tend to reduce or eliminate clearance delays (a significant problem when trying to move radio equipment across borders)

The new system also introduces several advantages over the regular systems, including

- The use of in-phone GPS units can automatically add location data to reports
- GPS can also be used to monitor the safety of volunteers
- Store and forward enables the implementation of creative reporting procedures (e.g., flying a model airplane with a phone attached over an inaccessible disaster site)
- The same equipment can be used to access the cellular network when it is available. That means money can be pumped into the local economy after a disaster through purchase of telecommunications access, while maintaining the resilience of an independent infrastructure capability.

Mobile Data has been successfully field tested by Gamma in a field simulation. The system was being refined and prepared for deployment when I conducted interviews.

The story of the development of the Mobile Data project began many years ago. One of the most challenging aspects of successful disaster response is the setting up of infrastructure to manage communications and information flows within the disaster zone, and between the responders in the zone and the central organization. The equipment needed for this function is expensive, heavy and complex. Certain elements of the system, such as VHF repeaters, need expert tuning at set-up, as well as expert

maintenance. They were also difficult to transport into and out of countries, because spectrum regulations vary from country to country and getting local authorities to allow the importation of radio equipment often called for extensive negotiations. For these and other reasons, several persons who were involved in the process had repeatedly suggested to MP that he should deploy mobile phones in disaster zones, rather than expensive, heavy radio equipment.

One of MP's duties is to constantly develop new and better technological solutions for the needs of responders in sister zones. He is constantly looking for ways to make the equipment that is deployed with his teams lighter, smaller, and more effective at getting the job done. However, mobile phones are dependent on the communications infrastructure, and are useless for communication when the telecommunications grid has been disrupted. Since this is often the case in areas where Gamma's response teams are deployed, MP decided it would be impractical to depend on mobile phones.

Another important part of the story occurred at approximately 22:00 hours UTC on January 12, 2010. PT, a lecturer at major university in Australia, was driving to work when news about a major earthquake in Haiti was broadcast on the radio. What followed is best told in his words:

*“ ...the defining moment for the [Mesh] project was when I heard about the Haiti earthquake on the radio on the way into work and, as is human nature, we like to try and make ourselves feel a little bit better about situations when they occur and so it was sort of seeing that and I realized immediately that it was the loss of communications capability was going to be a big problem for the people and that it was going to have, you know, loss of law and order and things were very likely to result. And so it was sort of thinking to myself, ‘well hey, they can ship in by air with communications equipment and hopefully get it back up in that sort of about three day window that you really have to prevent chaos from ensuing.’ And while I’m thinking this happily to myself, the person on the radio basically is reading off the report there and says that the airport in Haiti has been reduced to one runway and that one runway is carrying one plane every thirty minutes in or out. And I thought, ‘hmm, ok, they’re not going to fly stuff in, but that’s alright, I’m resourceful,’ I can think about other ways that they can get the gear in and, you know, me not have to face this reality of what they’re going to have to deal with then. So well, you know, Dominican Republic and Haiti are joined by a highway, they would be able to truck communications equipment in and also, you know, gear to set up the runway. So I’m thinking this happily to myself and the person on the radio says ‘and practically every road in Haiti has been destroyed by the earthquake,’ so I’m sitting thinking, you know, ‘this is kind of bad, but I’m a resourceful person, and Port au Prince has a harbor, so they’ll be able to ship in, cargo ship in, Dominican Republic or wherever the nearest harbor is that they can fly into a put a lot of stuff onto a cargo ship*

*and, you know, sail it quickly round to the harbor and start rebuilding from the harbor out.’ I’m thinking this happily to myself when the person on the radio says, ‘and the harbor in Port au Prince has collapsed.’*

*And I still just remember the rawness of that moment and just going, ‘well there’s actually no way that they can deal with this,’ and it’s actually interestingly I mean it’s actually the definition of a disaster by many accounts is an emergency when there is not the capacity to respond. So it was clear to me that, you know there was this disaster that was going to transpire there in Haiti and as I’d thought about it over the next few, well very quickly realized that something ought to be done, that the mobile phones becoming useless in people’s hands was a great tragedy and an unnecessary one. And so yeah starting thinking about, you know, airdrop in, you know almost Transformer-like, self-assembling phone towers that would park themselves on the ground and pop out a solar panel or two and set up/mesh radio links to one another and this was all fine and wonderful and completely impractical - well actually not completely, it actually could be done - but what I realized, actually, the more I thought about it, was actually the mobile phones already had the means to communicate with one another. It really is just an accident of history that they’re not enabled to do so.”*

PT began what would become the Mesh project as a collaborative effort within the university where he worked. It expanded to a project across several countries to build an open-source software solution that would allow mobile phones to communicate without infrastructure. MP heard about the Mesh project and the two of them, along with their respective teams, began to collaborate on getting the Mesh system integrated into a solution that could be deployed to responders in disaster zones. They began to integrate the direct-communication and store-and-forward functions in Mesh into a system that met Gamma’s operational needs.

Another element of the system was added in August 2011 when MP, at a trade show, saw the Tracker product, which at the time had not yet been released to the public. Tracker had been developed by its manufacturer as an emergency beacon for hikers, hunters, and other persons traveling through wilderness areas where there was no telecommunications infrastructure. MP started negotiations with the manufacturers of Tracker to try to get them involved in the development of Mobile Data, but their own conceptualization of the uses of the device they had built was very different from MP’s. Finally, after lengthy negotiations, they agreed to join the project. The makers of Forms also joined the project, and the entire team worked for several months to produce a working integrated system.

MP, who was the main driver of the project, has developed a network of expert volunteers who assist him in developing good ideas and getting them implemented. One of those volunteers — one who was critical in getting the Mobile Data project completed — is an expatriate engineer who moved to New Zealand

several years ago who I will call KF. While I was talking with him about Mobile Data, KF mentioned another idea which he had had about two weeks before we spoke. It involved using mobile phones as file servers in disaster zones. A lot of complications in disaster zones resulted from the need to maintain traditional PC file servers in the base camp office. Using mobile phones with large-capacity SD cards would eliminate a lot of the complications involved in using traditional hardware and software which has built-in capabilities for security and user management which are unnecessary and waste time under disaster conditions. The low cost of the hardware would also enable redundancy and allow multiple ‘servers’ to be deployed where needed instead of being centrally located in a ‘base’.

Just as was the case in Beta, I immediately noticed what seemed to be structural similarities in the nature of the problem space and the proposed solution between the Mobile Data idea and the file server idea. I asked KF if the file server idea was related to Mobile Data, and he replied that it was unrelated. When I asked KF where the idea had come from, he replied:

*“... I forgot, it’s just - because I think I was at the training exercise and I thought like, this is stupid, like - I actually had to watch people go through the exercise and evaluate them, so I thought, well, if we just used a Smartphone it would be done like, in a much shorter time, and with much less knowledge, because they had all these components like bad cables and like sticks and cables and so on, because they have to do problem solving.*

*The problem solving becomes much less because there is much less that can go wrong if it’s one concise package.”*

MP, who was there when I asked the question, agreed that it was a new idea, and they both explained to me the difficulties caused by using PC-based file servers and the ways in which using smartphones with large SD cards as servers would be an improvement over the equipment that they currently deployed with their response teams. Neither of them seemed aware of the similarities I perceived between their explanations of the advantages of smartphone servers over the current servers, and their explanations of the advantages of Mobile Data over their current communications infrastructure.

#### **5.4.2 Negative Cases**

In these organizations, conditions were found that many theories suggest should be conducive to creative action. Despite this, no cases of creative appropriation were found. Findings in these organizations proved valuable in enhancing understanding of the mechanisms identified through the main retroductive analysis.

#### **5.4.2.1 Kappa**

Kappa is a company that is based in the South Island of New Zealand. It is a small company whose primary business activity is operating a mobile surgical facility which operates across all of New Zealand. The mobile surgical facility is housed in a large semi-trailer rig. A trailer head (a large truck designed to tow semi-trailers) tows the rig to areas of New Zealand which are remote and do not have easy access to medical facilities. The trailer is a fully equipped mobile surgical facility which has a built-in leveling system. The rig moves around New Zealand on an annual schedule performing minor operations in remote areas that are otherwise underserved by medical and surgical resources. I was granted access to the company by the founder-manager, a senior surgeon. The company's IT assets are managed by a pair of senior engineers — who I will call DL and DS — who both had long careers in industry before they joined Kappa, including stints at IBM and Siemens. I interviewed both of them at the company's headquarters.

Information and communications technologies are a critical part of enabling the facility to function. For example, the kinds of collaboration and consultation that would normally take place in a hospital have to be conducted through secure IT links when the rig is deployed in remote areas. The internal operations of the company also utilize IT a great deal. DL and DS are both highly experienced IT engineers, both of whom had several years' experience in major technology companies before joining Kappa. Both engineers are deeply involved in the IT aspect of all Kappa's operations, both medical and administrative. Both engineers were able to state categorically, that they had seen no instances of creative appropriation of IT in any of the units of the business.

Both engineers were also in agreement on why they think this is so. They said that Kappa is a small company and that any user requirements — feature requests, problem reports, etc. — come directly to them and are dealt with quickly. Both of them had found, in their former jobs, that users become creative when they don't have easy access to IT resources. Required system modifications take time, and frustrated users find innovative ways around problems. In Kappa, in contrast, *"...about half of our users are within about a 20 meter radius of our desks. They just walk over and you can often make a change that day, tweak a system within an hour."*

#### **5.4.2.2 Theta**

This company is a small and dynamic software developer based in the South Island in New Zealand. It has an 'open plan' office in which all teams are co-located and is led by a CEO who is also an active developer. They have developed projects for a number of major entities in the entertainment industry, including US and European companies which are household names, and are quite expert at what they do. They also have a culture of experimentation: they have invested quite heavily in 'trying out' new technologies. For example, they invested time and effort into building flash games for mobile platforms when it was clear that the hardware was not powerful enough to run it at acceptable speeds for a commercial product, in

order to test their ability to do it. My informant was one of the founders and is now Chief Innovation Officer at the company. I will identify him as SM.

Theta has a highly skilled team of programmers, designers, graphics artists and other specialists. They have completed projects for major companies that are household names in media, entertainment and gaming in a number of countries, including the UK, Canada and the US. While they have a heavy work schedule and tight deadlines, the internal culture of the organization values creativity and experimentation. For example, SM showed me a demo of a game running on an early version of a certain mobile platform using a certain application runtime environment. The version of the hardware that the game had been developed for does not support a level of performance that would make the game playable for commercial release, and the designers at Theta knew this. They built the game, SM told me, not to make a profit, but “*to see if we could do it*” since developing in that environment for a mobile platform had special challenges.

Despite the presence of a highly skilled technical team, an environment which encourages experimentation and an organizational culture that is supportive of creativity, the company could not identify any instances of employees finding creative ways to apply IT systems. SM was surprised by this, and asked his team to double check this finding, as both he and I had expected that numerous examples of creative appropriation would be found in the organization, given its culture and the kinds of people who work there. However, no such cases were found.

### **5.4.3 Natural Experiments**

There were two organizations in which I conducted data collection that greatly contributed to the findings of the study, but did not actually contribute specific cases which were part of the retroductive analysis. In each of these cases, specific patterns noted in the data were analyzed at the collective level by applying replication logic, in the manner recommended by (Yin, 2009).

In organization Eta, I was briefed on the company’s internal change and innovation processes, conducted several formal interviews and a large number of informal interviews. I also attended the company’s annual Innovation Day, or “hackathon”, where I saw many improvisational solutions by engineers which may become the basis for future products. While none of the specific cases that I looked at in Eta are included in the analysis that I did in this study before reaching theoretical saturation, it contributed to my understanding of creative appropriation in unexpected and unintuitive ways. In organization Phi, a serendipitous (from my perspective) set of circumstances set up a kind of “natural experiment” in which two systems within the company exhibited very different patterns of creative appropriation.

In each context, information from the organization contributed to my findings, not through the analysis of a specific incident, but through a comparison of circumstances. In Eta, I was able to compare the type of

creativity that was apparent in the company (product creativity) with the type that was much rarer, or nonexistent (use creativity). In Phi, I was able to compare a system and context which triggered high levels of use creativity with one that did not. Because in each case I applied replication logic in order to learn about different aspects of creative appropriation, I have classified both of these cases as “natural experiments”.

#### **5.4.3.1 *Eta***

Eta is an engineering firm that builds motorized accessibility devices for disabled persons. They are an NZ company that is now part of a US-based group, but they operate fairly autonomously. Because their products are essentially medical devices, they have extremely stringent quality control procedures and documentation and reporting rules. They are regularly audited by the US Food and Drug Administration (FDA) and other regulatory agencies. They have developed rigorous procedures for ensuring that their products are up to code, and maintain documentation to demonstrate that the necessary testing and quality control procedures were followed for each product. With the support of the local management I was granted access to the company by the US corporate office and my principal informant was a senior manager in charge of developing new technologies at the company who I will call IR.

Eta has an extensive and highly organized formal process for evaluating requirements and market opportunities, generating and evaluating ideas, and designing and developing technologies for implementing those ideas. The level of formalization is, in part, driven by their reporting requirements as a medical device company. Eta is regularly audited by regulatory agencies from different countries in which their products are marketed. Their products are subject to stringent documentation and testing, as a result. However, the need to innovate and offer new and improved solutions to patient needs is also a high priority. Because of the stringent testing requirements for their products, there is a constant pipeline of experimental products being tested. The administrative, research and development, and production facilities are housed in a single large compound, and an upper floor of the main building contains a “test run” in which engineers can try out experimental features in an artificial environment with an obstacle course and ramps. When I toured the facility, this test environment seemed quite popular.

The walls of Eta are covered with whiteboards and drawing tools and, in some cases, are designed to be drawn on directly. Workspaces are configured to enable teams to collaborate easily and without undue mediation. Eta also has a formal process for submitting, evaluating and developing ideas about how it can improve its internal processes. Employees can submit ideas into a system via a panel with diagrams of the process and boxes for change requests, located in a main hallway. There is a process by which each of these ideas are reviewed by an internal review group comprised of representatives from each major functional area of the company. The review board is able to facilitate collaboration across functional groups to implement ideas which “make the cut”. The display panel is designed so that the progress of each idea through the system is transparent and can be tracked by the person who submitted it. The

internal atmosphere is focused, but there is a lot of easy banter, and employees can often be seen using the visual aids in workspaces, having meetings in spaces designed for ad-hoc gatherings, etc.

I investigated a number of incidents in which users appropriated technology in unexpected ways in Eta. In one case, an engineer whose hobbies include an interest in obsolete communication protocols, found a way to use one of those protocols — one that had been designed for data transmission on media with high “noise” levels — as a solution for designing control inputs for users who lacked fine muscle control. Another incident was the implementation of a records management system in which the Eta engineers developed such a novel and useful solution that the developers adopted their solution and integrated it into the next version of the software. I also attended the company’s annual “hackathon” (formally: Innovation Day), in which a number of current problems were put up on a board, teams of employees picked a problem, and were given six hours to “hack” together a solution using available parts. I saw a number of unexpected and insightful solutions to problems, some of which may make it into future products.

For various reasons, the incidents I investigated at Eta were not included in the retroductive analysis before theoretical saturation was reached. However the larger insight about creative appropriation that it contributed to the analysis lay in the differentiation between two types of creativity that I saw within the company. In terms of *product* creativity — where creativity was a deliberately-sought goal state in terms of maximizing the utility of the firm’s physical products — Eta was highly innovative. The time and resources that Eta’s management invests in this kind of creativity has resulted in a series of innovative products which have given the company a reputation for creativity within its industry. However, in terms of *process* creativity — where creativity is a goal state in terms of maximizing the utility of the firm’s internal processes — Eta was only modestly innovative.

This is despite the fact that this kind of creativity (process) is a consciously-sought goal in the company, as reflected in its highly designed change process. A lot of resources were invested in the development of the change process, and the time and effort of a lot of busy managers are invested in its operation. Despite this, the ideas that successfully make it through the change process tend to be fairly modest in scope. SG, the leader of the section that runs the change request process, explained that issues often arise with the most complex ideas. He described them as follows:

*“... in theory, this works really smoothly and this works really well and gets people involved. But what tends to happen is that some of the ideas people bring to the table but they’re not really willing to drive it. So they really want other people to drive it, in which case, we try to help that out and we try to get the right people involved, but if it’s not really going anywhere then a lot of those can stall. So people don’t necessarily have the willpower or the engagement to drive their own ideas.”*

Ideas which are low in scope and bring immediate benefits tend to be implemented quickly. However, ideas which involve more work and longer commitment tend require investigation of their projected effects, coordination between different functional areas, assessment of costs, and other processes that require at least one very interested person — a ‘driver’ — in order to make the idea happen. SG described what tended to happen with such ideas:

*“... So a lot of the issues we actually have is the things that have been in there a long period of time tend to make less progress than ones that are raised now. As we’ve been developing the overall process it’s becoming better and better, so we’re getting better at bringing people down and talking about their idea and moving and progressing it on. But if we don’t do that in a timely manner, then things tend to stagnate and people tend to lose focus on it. So things need to be processed quickly and continued to be pushed for us to make progress with it. If they sit there for a long period of time, there’s potential that they’re just going to stagnate.”*

Despite the fact that this process was designed to facilitate the nurturing and implementation of ideas about how to perform internal processes — including the appropriation of IT systems — in better ways, the change process was not the source of any of the incidents of novel and useful appropriation of IT that I identified at Eta.

What Eta did contribute to my analysis was one fundamental insight: *creative appropriation does not just happen*. Not only does it not just happen, but it is very hard to facilitate and encourage. Even when major resources, technical skill and an encouraging organizational culture are applied, really novel, surprising appropriation patterns do not emerge without significant triggering conditions. This is, of course, a triangulation of the finding in one of the “negative cases” — the software developer Theta. Eta was not a “negative” case (some cases of novel and useful appropriation were found there), but again there was the pattern of a highly innovative organization, which was very successful at product creativity, showing much less process creativity than might have been expected, given the environment.

#### **5.4.3.2 Phi**

Phi is a multinational firm that sells access to cloud-based accounting software for small to medium-sized business customers, using an online subscription-based model. It was founded within the last ten years and has grown rapidly since its inception. It is based in a city in New Zealand, and has operations in New Zealand, Australia, the UK, and the US. I looked at several interesting cases within Phi, but what stood out — and what I have focused on for this project — is an interesting natural experiment occurred across departments in the firm. My primary informant was the chief software architect at the firm.

Phi’s policy is to ‘eat its own dog food’, and so it runs a part of its own accounting operations using the software that it sells to customers. I spoke with the head of the Finance department, whose team handles

payroll, accounts receivable and payable, and all other financial functions for the entire firm. To do this, they use Phi's software. However, there is a serious mismatch between their needs and the software that they sell. Phi is a multinational company that operates across several different regulatory environments in different countries with different currencies. They are also publicly listed and subject to stringent reporting requirements. They have highly trained staff to meet these needs, but many of the features they need are not to be found in their software. It is aimed at small to medium-sized business owners who want to be able to run their businesses without hiring an accountant. In response to challenges which arise from this, the Finance department has direct dialog with the developers of the software on a regular basis. Features which they need that would also be useful for customers are added to the commercial product. Features which they need which would not be useful for their target market (e.g. the ability to handle an international payroll in multiple currencies), or which cannot be added quickly, are outsourced to partner companies. There were no instances of creative appropriation of the IT systems that they use which the head of Finance could identify.

Phi also uses an internal business-process management system that I will call Process for internal business process management (BPM) purposes. Process is not available to the public and is not a commercial product. It was developed in-house for the company's needs, and until recently it had a single developer working on it. I spoke with the developer who runs the Process team (which, until recently, had one member: himself). He was able to tell me about seven significant cases of unexpected uses of the Process system by users that he had observed, spontaneously and without preparation. Apparently, users are continually coming up with new ways to "hack" Process, and use it in ways which were not intended or expected by the developer.

#### **5.4.4 Corroborative Interviews**

One of the requirements for mechanisms identified in a critical realist study is that they must adequately represent reality (Wynn & Williams, 2012, p. 801). After the retroductive analysis, as part of the empirical corroboration phase of the project, interviews were done with participants from organizations who would have a good intuitive grasp of typical user behaviors based on their roles. One is a consultant with years of experience in eliciting user requirements for complex systems, the other a security consultant who has extensive experience in analyzing how some users may unexpectedly appropriate complex systems by breaching their security.

##### **5.4.4.1 *Lambda***

Lambda is security consultancy that specializes in penetration-testing. It employs consultants who are, essentially "white hat" hackers. They are typically called in to test the security of e-commerce and other public-facing websites that access or store sensitive data. They do so by conducting simulated attacks, using techniques and tools similar to those used by malicious hackers and cyber-criminals. They are often

called in by companies who are preparing to deploy new web-based services, and a certification from a company in their line of business is a requirement for doing business in some industries.

After the retroductive analysis, I interviewed a consultant at Lambda to assess the explanatory power of the mechanisms identified. We spoke about the common tendencies he observed in terms of how programmers worked when building secure websites, and how he and his colleagues made judgments about how programming teams worked, and figured out which tests to use at sites.

My findings from this interview were consistent with what I expected from the mechanisms that I had identified.

#### **5.4.4.2 Delta**

Delta is a consulting firm that develops bespoke IT solutions for clients. They see themselves primarily as a design firm, but they design systems that involve IT. The solutions they develop often have both hardware and software elements. My interviewee was the founder/owner of the company, who is an active consultant and is also a leader in the New Zealand IT community. We discussed how users typically appropriate systems after deployment, as well as the communication process between developers and customers, and how this is affected by factors such as background and experience on each side.

My findings from this interview were consistent with what I expected from the mechanisms that I had identified.

## **5.5 Initial Observations and New Research Question**

As recommended by Eisenhardt (1989a), the study was begun with no preconceived model of what causal relationships would be found. The initial plan was to collect data about what happened in each case – with special attention being given to the a priori constructs drawn from Amabile (1996) – and see what emerged from examining cases in which systems were appropriated in a novel and useful manner. The assumptions being applied at the time were the positivist/empiricist assumptions that Eisenhardt (1989a, p. 546) states are reflected in her approach. In her own research, based on this method, the form of the theory that was developed was a synthetic variance theory (Langley, 1999), and this seemed consistent with the type of explanation I was trying to develop. I was therefore looking for patterns of factors at work in cases of successful creative appropriation that could be synthesized into an explanatory model. The second participant organization visited during fieldwork was Theta, the software development company. Despite the fact that Theta had high levels of the components that Amabile suggests are required for creative discovery at both the individual and organizational levels (Amabile, 1988, 1996), and despite the fact that the CEO expected that we would find several instances in which his staff were using their systems creatively, we found none.

I realized that *not* finding creative appropriation in a context where it would be expected to occur was an interesting finding, and might contribute a great deal to an understanding of the phenomenon. Nonetheless, the then-current design of the study was poorly suited to learning from such a context. If there was no “case”, then there would be no pattern of factors to observe. As such, I decided to change the form of explanation from a synthetic variance strategy (Langley, 1999) to a mechanism-based strategy (Hedström & Ylikoski, 2010). The mechanism-based strategy is not tied to a single set of metatheoretical assumptions, and is not necessarily critical realist. However, the critical realist model provides a set of principles that can guide the construction of a mechanism-based explanation (Wynn & Williams, 2012), and I found it a logical and compelling view of the nature of reality which I believed formed a sound foundation for theorizing (Easton, 2010). I therefore adopted critical realist assumptions, and changed my research questions to fit the new approach.

The form of the research questions in a critical realist study take a standard form based on the goal of identifying mechanisms (Wynn & Williams, 2012, p. 804). A single research question was then adopted. It was:

- *What are the mechanisms that explain end user creativity in the appropriation of Information Systems at the individual level?*

Given the theoretical replication strategy followed in selecting cases, I was able to observe creative appropriation happen in a number of different contexts, under different conditions, with the actual ideation and enactment processes involved being conducted by different users with different backgrounds and properties. The users used different kinds of systems for different tasks, and, in some cases, there were different teams of users using different systems who worked collaboratively to appropriate systems. The theme that emerged from the case data was *patterns of information processing*. There were certain ways that people processed information that were recognizable across cases. I also noticed that these ways of processing information seemed to apply, not only at the individual level, but also at the collective level.

It was clear, also, that it would be meaningless to try to describe individual-level processing without reference to the collective processes in which that processing was embedded. The scope of the thesis was limited to explaining creative appropriation at the individual level, but appropriation always occurred in a collective context. At times, what made a solution successful was not the work of a single “creative” individual, but the collective effort of a group, or several groups. It therefore became apparent that, even if I was proposing an explanation that was limited to the individual level, I would need to use language that could account for collective-level processes.

## **Chapter 6. Data Analysis**

### **6.1 Introduction**

In this chapter I describe the analytic procedures that led to the identification of the mechanisms, and the development of the integrative model that shows how the mechanisms work together at the individual level. Although in critical realism analysis is recursive and parallel, the analytical process in this study can be thought of as having two major components. The first component is the development of the theoretical framework that will be used to theoretically redescribe the data (Wynn & Williams, 2012, pp. 796, 809). The second component – which relies on the first – is the actual retroductive analysis that identified the mechanisms.

I will therefore proceed by first describing the development of the framework, then explaining the retroductive process.

### **6.2 Structural Analysis**

Data was collected in each participant organization. Interviews, transcripts and documentation collected were imported into the NVivo case database. Extensive field notes were made, encoded to audio and imported into the case database. Where code samples and artifacts could be converted into an NVivo-friendly format this was done and they were imported. Where it was not possible to digitize or convert case materials, descriptions were made in text documents and these were imported. In conformance with (Eisenhardt, 1989a), data analysis was started and carried out in parallel with the collection of data.

The first step of a CR analysis is to “identify and analytically resolve the components of the structure that are causally relevant” (Wynn & Williams, 2012, p. 798). The challenge of structural analysis was therefore confronted quite early in the research process. The fact that the cases were theoretically replicated (Yin, 2009) increased the dimensionality of the data and, with it, the potential complications of identifying the structures that were causally relevant, not only in a single case, but across all the cases. It is for this reason that Wynn and Williams (2012) suggest that because of the complexity of structural analysis, CR case research will normally be idiographic in nature (Wynn & Williams, 2012, p. 804). However, both Wynn and Williams (2012) and Hedström and Ylikoski (2010) mention the use of existing theoretical knowledge about the phenomenon under investigation as a way to get at the underlying structural elements of the causal mechanism.

It was necessary to do this by theoretically redescribing the data (Wynn & Williams, 2012, pp. 796-798, 809). I looked at a number of existing theoretical frameworks, but found none which were a satisfactory fit for the kinds of structural analysis that I was conducting. The historical developments described in

Chapter 2 may explain why this was the case. Since a suitable analytical framework did not exist, I needed to build one. Below I outline the process of developing that framework.

## **6.3 Developing AFT**

The framework whose development is described below is named Affordance Field Theory (AFT). It is proposed as a tool for redescribing case data to enable the analysis of appropriation activities across cases, in different spatial and temporal contexts, using a common set of conceptual objects, actions and relationships. The need for a “common language” to aggregate knowledge gained in different contexts is an issue that has been discussed at length in IS (Benbasat & Zmud, 1999; Davenport & Markus, 1999; Moore & Benbasat, 1991). The arguments are complex and not easily amenable to simple reductive summarization, but many of them have to do with the tension between the need for common concepts to enable the accumulation of knowledge (Benbasat & Zmud, 1999), vs. the potentially restrictive effects of the constraints of using a common set of concepts (Davenport & Markus, 1999). The settling of this debate is beyond the scope of this thesis, but the underlying issues are relevant. On the one hand, in order to make the claim that I am inductively developing theory that is grounded in the data, it is necessary to let the data speak, so to speak, by not pre-applying theoretical assumptions about what will happen or what causal paths do or do not exist (Eisenhardt, 1989a). On the other hand, the data must be reduced to theoretical categories in order to facilitate structural analysis (Wynn & Williams, 2012).

To address these divergent requirements, AFT is designed to be a purely descriptive theory. It is Type I theory, according to the typology of Gregor (2006). It does not extend beyond analysis and description, does not specify causal logic or expected outcomes, and is axiologically neutral. Because of this construction, AFT is proposed to be a suitable tool for analyzing what happened in each case, without making implicit assumptions about how or why what happened, happened. It therefore useful for structural analysis, but does not unduly bias the retroductive analysis that guides the discovery of the mechanisms.

The conceptual categories used to analyze data must be based on theory (Moore & Benbasat, 1991), and AFT is based on well-established theories from a number of disciplines that have been integrated according to a well-respected framework. The foundations of AFT, and the process of developing it, are described below.

### **6.3.1 Adaptive Structuration Theory**

In 1985, scholars at the University of Minnesota embarked on what would become a decades-long research program probing the effects of computer systems that facilitated collaborative decision-making (called Group Decision Support Systems, or GDSS) on group processes and outcomes (DeSanctis, Poole, & Ziggers, 2008). After initially developing a taxonomy for describing GDSS systems and the environments

they function in (DeSanctis & Gallupe, 1987), the researchers were faced with the need to integrate and synthesize results across a number of subsequent studies. This task was complicated by the fact that then-existing research on GDSS had produced conflicting findings on the effects of those systems (see Poole & DeSanctis, 1989, p. 149). Since the existing literature did not offer consistent guidance in terms of the assumptions that should be brought to the problem, DeSanctis and Poole sought to blend insights from what they considered the two dominant schools of thought in the study of the impact of IT in organizations: the deterministic (i.e., positivist-oriented) “decision-making school” and the interpretivist “institutional school” (DeSanctis & Poole, 1994). They developed an integrative perspective inspired by Giddens (1984)’s theory of structuration, which they called Adaptive Structuration Theory (AST).

Although AST was designed to support their research program on GDSS, it was proposed as a general framework for the study of IT effects (Poole & DeSanctis, 2004). DeSanctis and Poole (1994) adopted a ‘soft-line deterministic’ position that views technology as providing rules and resources that enable and constrain human behavior (*structures* as defined by Giddens (1984)), while social practices moderate their effect on behavior. They proposed that advanced IT systems provide structures that can be described in terms of:

- *Structural Features* – “the specific types of rules and resources, or capabilities offered by the system (DeSanctis & Poole, 1994)”. This can be understood to be the full set of bundles of functionality that are provided by the system
- *Spirit* – the “general intent with regards to values and goals underlying a given set of structural features (DeSanctis & Poole, 1994)”. This is seen as a separate concept from the intentions of the designers. It is the ‘official line’ about how the system ought to be used, and emerges from the amalgam of influences which result in the final form of the system.

The structures within a technology system are brought into action as they are accessed and applied by users. In the process of enacting the structures within the technology, users may change them, applying or modifying the features in ways that are not consistent with the system spirit. While these processes may evolve over time, they can be observed by researchers through isolating and analyzing specific instances in which users make use of the structures within the technology – what DeSanctis and Poole term *appropriation moves*. Appropriation, a concept rooted in the work of Marx and Hegel, emphasizes the constitutive nature of using an object, the way that the act of use can redefine both the object and the user (Poole & DeSanctis, 1989). For example, a shovel is a *tool* for digging that may be used by a *farmer*. However, using it to hit someone over the head can redefine the shovel into a *weapon*; and at the same time, can redefine the farmer into a *murderer*. Therefore, the nature and effect of a technology and its user, are contingent on how that technology is appropriated. Incidentally, this represents one of the few instances in which a concept from structuralism has been included in a mainstream theory within IS (see (W. Chen & Hirschheim, 2004) citing (Hirschheim & Klein, 1992)).

In AST, appropriation moves involve

- a) Making choices about how to use technology structures
- b) Choosing to appropriate technology features *faithfully* – in a manner consistent with the spirit of the system and the design of the features; or *unfaithfully* – out of line with the system spirit
- c) Selecting different instrumental uses for the technology, and
- d) Displaying different attitudes as the technology structures are appropriated.

AST was a significant contribution to IS (Markus & Silver, 2008) and has become one of the most influential frameworks in the discipline (Bostrom, Gupta, & Thomas, 2009). However, despite its wide success, or perhaps, precisely because of it, it has also been severely critiqued by researchers both within and outside of the discipline. I will discuss this critique, in turn.

### 6.3.2 Critiques of AST

While recognizing the contributions of AST, Markus and Silver (2008) point out three major concerns with it that have been raised in the literature:

- Viewing structural features and spirit as sources of structure – in the sense of Giddens – contradicts Giddens’ own definition of structure. Giddens was a sociologist, concerned with the influence of social structures on individual human agents, and vice versa. He regarded structure as being embodied in human ‘memory traces’ (Giddens, 1984), and explicitly rejected the idea of structure being able to exist outside of the action of social actors in artifactual objects (for a fuller discussion, see (Jones & Karsten, 2008, 2009; Poole, 2009)).
- Analyzing structural features can be problematic for researchers because of the need to conduct feature analysis at a certain level of abstraction. At any given level, system features are made up of lower-level features which are made up of lower-level features, ad infinitum. There is no clear stopping rule to guide researchers on what point is appropriate for terminating elaboration of sub-features. This *repeating decomposition problem* is inadequately addressed by the measures proposed by DeSanctis and Poole (1994).
- DeSanctis and Poole (1994) define the spirit of the technology as “the general intent with regards to values and goals underlying a given set of structural features”. Many theorists reject the attribution of constructs such as ‘intent’, ‘values’, and ‘goals’ to non-human artifacts (Jones & Karsten, 2008).

Markus and Silver (2008) point out that, partly as a result of concerns such as those listed, the concepts of structural features and spirit have not been nearly as widely adopted by researchers as the concept of appropriation.

### 6.3.3 Markus and Silver

To address the aforementioned concerns, Markus and Silver (2008) have proposed an updated model of AST. This model replaces the concepts of Structural Features and Spirit with three new concepts: *Technical Objects*, *Functional Affordances*, and *Symbolic Expressions*.

These are defined as follows:

**Technical Objects** are IT artifacts and their component parts, including user interfaces and ‘boundary objects’ such as charts, graphical representations and other outputs which are directly accessed by users. They are *real things* in that they do not depend on human perceptions in order to exist, and as such, have properties, which may range from physical (e.g., color), to abstract (e.g., reliability) characteristics. Technical objects are typically made up of component technical objects, and are therefore subject to the repeating decomposition problem that also affects DeSanctis and Poole (1994)’s Structural Features concept. The two relational concepts – functional affordances and symbolic expressions – included in Markus and Silver (2008) are intended to address this problem.

**Functional Affordances** are a relational construct linking an animal (in an IT system-use context, typically a human) to (technical) objects in its environment. Markus and Silver define it as “a type of relationship between a technical object and a user (or user group) that identifies what the user may be able to do with the object given the user’s capabilities and goals”. The concept of the functional affordance enables the researcher to limit the range of technical objects examined with reference to the level of the goals of the user.

The concept of functional affordances is developed from the work of (Gibson, 1977, 1979). A perceptual psychologist working in the field of visual perception, Gibson invented the concept of affordances to describe the set of possibilities for action offered an animal by the features of its environment. He defined the concept as follows: “An affordance of anything is a specific combination of the properties of its substance and its surfaces taken with reference to an animal” (Gibson, 1979). Affordances are not classifications: just because an object affords sitting does not make it a seat. They are, rather, action potentials created by capabilities of the animal and properties of the environment. Affordances may be communicated to the animal by means of various signals, such as optical information (Gibson, 1979, p. 140), but they are a separate concept from the animal’s perceptions.

It is worth noting that there are actually two versions of the affordance concept in the contemporary literature; two versions which are related, but distinct. In the ecological psychology literature, there is a rich literature on affordances in the Gibsonian tradition: non-deterministic relationships describing action potentials between animals and aspects of their physical environments. However, in the literature on design science and human-computer interaction, there is an identically-named concept of affordances.

The literature on this branch of the affordance literature concept has its origin in Norman (2002). In this work, Norman interprets the concept of affordances as mental interpretations of things, based on past knowledge and experience (Norman, 2002, p. 219), and acknowledges that this interpretation is in conflict with the views of many Gibsonian psychologists. Conceptualizing affordances as mental representations fit with Norman's purpose of communicating principles that could guide designers in creating artifacts that contain clear perceptual information about how they should be used. However, it did so at the cost of creating potential for confusion across the ecological and design literatures.

Markus and Silver (2008)'s conceptualization of functional affordances makes it clear that they intend to draw on the Gibsonian version of the affordance concept, and they explicitly cite the ecological psychology literature of which Gibson's contributions are the foundation.

***Symbolic Expressions*** are a relational concept linking the properties of a technical object with the interpretations of that object by the user. Markus and Silver define it as “the communicative possibilities of a technical object for a specified user group” Markus and Silver (2008, p. 622). They draw on literature from the discipline of semiotic engineering. Semiotics is the study of sign systems and communication (De Souza & Preece, 2004). It is fundamentally concerned with signs - anything which can be substituted for another thing in human communication (De Souza & Preece, 2004, p. 583). This domain is necessarily large, and its boundaries can be difficult to identify. Eco (1979) defines it as “the discipline studying everything which can be used in order to lie”, proposing that if something cannot be used to lie, then it cannot be used to convey truth. Therefore semiotics is concerned with symbol systems, communication channels, and all other things which can be used to convey information, in such a way that the sender can have any discretionary control over the meaning conveyed by the message.

Markus and Silver (2008) see interactive computer systems as having interfaces which can serve as messages from designers to users about how to interact with the system in order to attain desired goals or experiences. However, this is not the only source of symbolic expressions in their conceptualization. Other sources, such as contextual factors, public information and cultural norms, can also create symbolic expressions: either directly, by assigning values to the technology itself; or indirectly, by assigning meanings to properties of the technology. An example of cultural norms creating symbolic expressions which may affect the message sent by an IT artifact may be seen in the example of Perlroth (2012). This article in the New York Times, titled “The Blackberry as Black Sheep”, reported on the shame and stigma that owners of the Blackberry personal communication device felt when using their devices around colleagues or relatives who have more modern and feature-rich devices made by other manufacturers. Such messages in the public sphere affect the perceptions of, and the messages conveyed by, technology artifacts — certainly, in this case, in ways that not intended by the designers of the Blackberry. The attachment of culturally-specific meaning to technology properties is another way in which symbolic expressions may arise which are quite independent of designers. For example, Markus and Silver (2008)

cite the example of the color red, which may convey very different messages to Western and Asian user communities. For this reason, they emphasize that symbolic expressions are not to be seen as properties of the system, but rather as relationships between the system properties and specified user groups.

Just as the concept of functional affordances is a relational concept that bridges the gap between the properties of a system and the way/s that a user can use that system, the concept of Symbolic Expressions is a relational concept that bridges the gap between the properties of a technical object and the interpretations of that object by the user.

### **6.3.4 Limitations of Markus and Silver**

Markus and Silver (2008)'s conceptualization extends that of DeSanctis and Poole (1994) in ways which address several concerns which have been raised by scholars, and their extensions have been usefully applied in subsequent research (Goh et al., 2011; Grgecic & Rosenkranz, 2010, 2011). However, Markus and Silver's conceptualization, by their own account, leaves room for further conceptual development. They make the point that a full explanation of IT effects cannot be complete without careful conceptualization of users and environmental contexts (Markus & Silver, 2008, p. 620); and they explicitly state that developing such conceptualizations is beyond the scope of their paper. Their omission of these conceptualizations makes sense in light of their stated goal in their paper: to enable researchers to construct better hypotheses for IT effects and design science research (Markus & Silver, 2008, pp. 614, 620-621, 627-628). Such hypotheses would, presumably, specify a range of user/s and context/s within which the testable predicted relationships would hold. However, this tends to obstruct the application of Markus and Silver (2008)'s model to anything other than hypothesis testing research.

The difficulties can be illustrated using one of the studies that has applied Markus and Silver (2008)'s reconceptualization. Goh et al. (2011) sought to understand the keys to a successful implementation of Health IT systems in hospitals. They explored this by looking at the case study of an implementation of a computerized document management system (CDS) at a large hospital in a major metropolitan area of the United States. They used the theoretical lens of organizational routines (M. C. Becker, 2004; Feldman & Pentland, 2003), and the analytical technique of narrative networks (Pentland & Feldman, 2007). To theorize the interaction between the CDS and the narrative of its implementation – i.e. how it was appropriated by users – they used Adaptive Structuration Theory, utilizing Markus and Silver (2008)'s concepts of functional affordances and symbolic expressions. This allowed them to examine the complex bi-directional interactions between the technology and its users (Goh et al., 2011, p. 569), and examine the role of agency in the unfolding of the case.

The following observations can be made from Goh et al. (2011).

- Markus and Silver’s concepts are useful and effective tools for examining the interaction between users and IT systems, especially in those situations where the intention is to open the ‘black box’ – understand the underlying dynamics of the causal influences on those interactions.
- Notwithstanding the above, the representations of functional affordances summarized in the narrative networks that are constructed omit crucial information that is relevant to a full understanding of the IT implementation. For example, one critical event that occurred in the transition phase of the implementation was that the mobile access carts for the system (known as Computers On Wheels, or COWs) began to fail because of insufficient battery charge. When COWs batteries failed while they were in use, it would cause the loss of any partially-entered data - leading to frustration, delays, and extra work (Goh et al., 2011, p. 575). This led to several effects, such as negative reactions to the system, and competition between teams of users for ‘possession’ of working COWs. However, because of the mono-dimensional nature of the functional affordance concept it is impractical to represent the complex nature of the type of failure and its several effects. It is simply represented as “Lack of workable COWs” in the narrative network.
- Symbolic expressions come from several sources and can be complex, ambiguous and contradictory. Different symbolic expressions can have different effects, and different levels of effect, on individual users. For example, during the pre-implementation phase of the implementation, users were subjected to positive symbolic expressions in the form of advocacy and marketing materials concerning the system. During the transition phase they were subjected to negative symbolic expressions as a result of problems with the system. However, through the action of agency in the form of interventions and statements of support from senior staff, negative symbolic expressions regarding the system were replaced with positive ones, leading to the eventual success of the project. However, in the representation of these processes: the positive and negative messages influencing users’ reactions to the system; and the reactions of users to both sets of messages, were depicted as ‘symbolic expressions’. This leads to considerable confusion and makes it difficult to represent what is actually happening in a theoretically abstract way.

The problems identified may be summarized as follows.

- The mono-dimensional nature of the Functional Affordances concept makes it difficult to represent the complex nature of user interaction with the properties of technical objects; interactions which can involve unsuccessful attempts to access existent features, mistaken attempts to access non-existent features, problems, and failures – rather than just the successful access of existing affordances.
- Symbolic Expressions can come from several different sources and can be complex, ambiguous, and contradictory. Different symbolic expressions can have different effects, and different levels of effect, on individual users. However, in Markus and Silver’s conceptualization, there is little

way to represent the lack of equifinality in the effects of different symbolic expressions since both the message and the effect of the message on the recipient of the message are represented by the same concept.

- DeSanctis and Poole (1994), in defining AST, proposed not only a set of concepts to represent embedded sources of structure in technology and its appropriation, but also a set of proposed relationships between those concepts and potential outcomes. This set of propositions, in conformity with the ‘soft deterministic’ stance that they followed, did not specify a set of causal relationships between inputs and outcomes. However, they did serve to focus enquiry and give direction about the questions that could – and ought to – be asked when applying AST to the analysis of empirical findings. Several of those propositions may need to be revisited in light of Markus and Silver’s modifications. For example, *faithfulness of appropriation*, a key concept in AST which describes the extent to which an appropriation move is consistent with the system spirit, loses its meaning when the concept of spirit is replaced with symbolic expressions. A new framework for linking AST concepts to user behaviors is therefore required.

Attempts to represent user perceptions and behaviors must make a trade-off between generalizability, simplicity and accuracy (Tate & Evermann, 2009). The concepts proposed by Markus and Silver (2008) appear to privilege simplicity at the cost of accuracy by making it difficult for researchers to represent complex appropriation processes while maintaining conceptual abstraction (Tate & Evermann, 2012).

In the next section, I will revisit the source literatures for the concepts proposed by Markus and Silver (2008), and will draw on further literature from cognitive science to propose a framework for conceptualizing the interaction of user, system and task in a more comprehensive way.

### **6.3.5 Extending Markus and Silver**

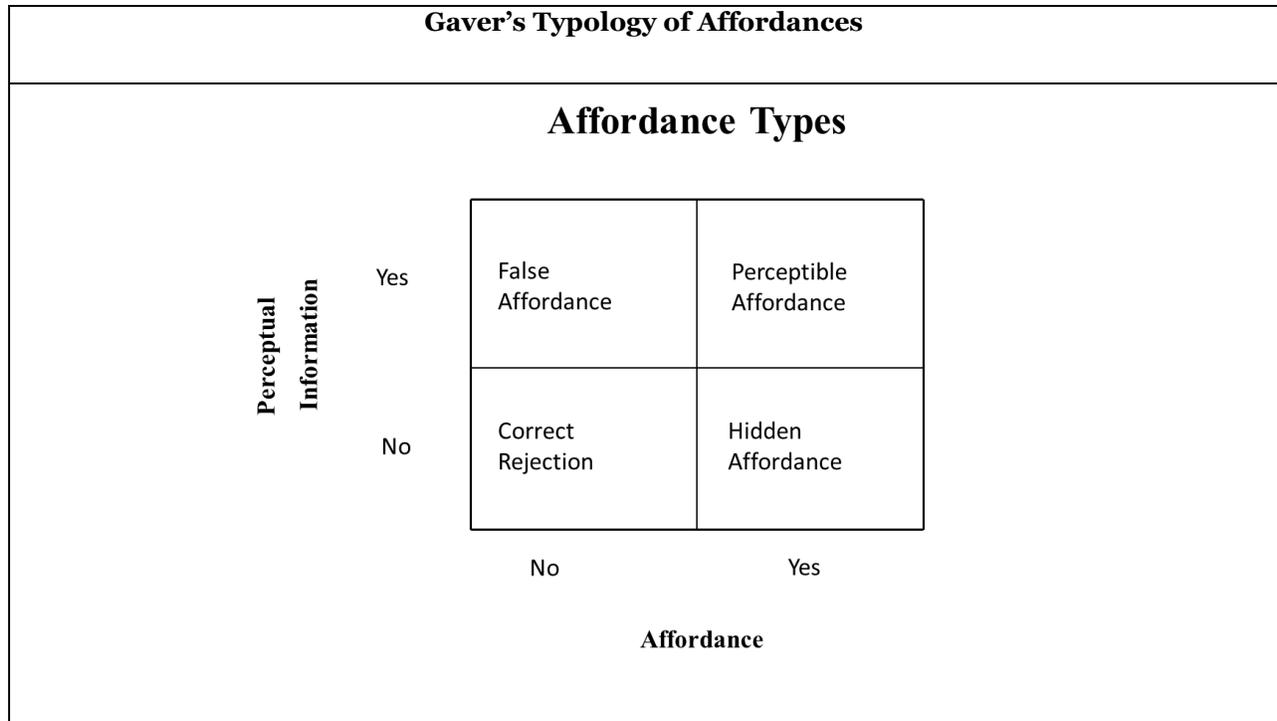
In this section, I propose extensions to Markus and Silver (2008)’s concepts in order to allow for a more detailed analysis of the appropriation processes involved in the use and adoption of advanced information technologies. Specifically, I look at affordance types, user effectivities, and system representations.

#### ***Affordance Types***

The concept of functional affordances is developed from the work of (Gibson, 1977, 1979). Gibson developed the concept of affordances to describe a set of possibilities for action offered an animal by the features of its environment. Ontologically, an affordance is not a property of an animal (the preferred term in ecological psychology) or an object, but a relationship between properties of the animal and the properties of an object. It represents an action potential created by the relationship between such properties. For example, the following question can be asked: If a man on a level surface is faced with a raised platform, does the platform *afford* the act of stepping up onto? The answer is not inherent in the

properties of the animal (the man) or the object (the platform) but rather a relationship between the properties of each – namely, if the height of the platform is 88% or less of the length of the man’s leg, it affords stepping (Warren, 1984). This is true regardless of the actual value of either property, and is not dependent on whether or not the man is aware of the relationship.

DeSanctis and Poole (1994) provided a typology of appropriation moves to guide researchers in conducting analysis. However, this typology is closely tied to the notion of technology artifacts as sources of structure, as their formulation assumes that technology has embedded social structures. It must therefore be revisited when considering affordances, which are not sources of structure, but avenues of agency. Gaver (1991) has extended the work of Gibson (1979) in a way that may fill the gaps in the current conceptualization of functional affordances, enabling them to convey more information about the way that users apprehend and utilize affordances in their interactions with IT artifacts. He proposed that since affordances are independent of perception, it is possible to separate an affordance (i.e., an action potential) from perceptual information about the affordance. On this view, he proposed the following matrix of affordances:



**Figure 6: Typology of Affordances**

Where perceptual information exists for an existing affordance, it is a *Perceptible Affordance*, which may be perceived and acted upon by a user. Where there is no information revealing the existence of an existing affordance, it is a *Hidden Affordance*, which cannot be perceived, but may be inferred from other evidence. Where existing information points to an affordance that does not exist, it is a *False Affordance* which may lead to errors as users try to act on it. Finally, where there is no information to suggest the existence of an affordance that does not exist, there will be a *Correct Rejection*. Gaver (1991) also noted that where objects afford complex actions those affordances may be *sequential*: acting on a perceptible affordance may lead to information indicating new affordances. For example, in a word processing program, the *Paste* affordance may be revealed only after the *Copy* affordance has been utilized. Affordances may also be *nested* in space: an icon – say a picture of a disk – may, by itself, afford *clicking*. However, in the spatial context of a toolbar at the top of an application window, the same icon may afford *saving* a file.

User innovation often involves exploratory behaviors, including learning by trial and error. They can evolve over time, and are often shaped by context (Jaspersen et al., 2005). Gaver (1991)'s extensions to the concept of affordances can therefore usefully extend Markus and Silver (2008)'s concept of functional affordances, giving researchers a tool for representing these complex interactions with IT artifacts over time.

### **User Effectivities**

Markus and Silver (2008) emphasize that functional affordances are possibilities for goal-oriented action afforded to specified users or user groups. Affordances can only exist where there is a match between user properties and the properties of technical objects which create action potentials in turn. A specific information technology which is programmable will offer certain affordances to a user with programming skills that it will not offer to a user who does not.

Shaw, Turvey, and Mace (1982) proposed a concept that can be used to represent properties of a user (or potential user) of a technical object – the concept of the *effectivity*. They used as a starting point Turvey and Shaw (1979)'s formalization of the concept of the affordance:

- A situation or event X affords action Y for animal Z on occasion O if certain relevant mutual compatibility relations between X and Z obtain

Then they defined the concept of the effectivity as:

- An animal Z can effect action Y on an environmental situation or event X on occasion O if certain relevant mutual compatibility relations between X and Z obtain

The concepts of the affordance and the effectivity are complementary: a situation or object cannot offer an animal an affordance if the animal does not possess the necessary effectivities (Michaels, 2003). As such, effectivities – which can include properties such as abilities and aptitudes (Greeno, 1994) – can parsimoniously be described as properties of animals that allow them to make use of affordances (Chemero, 2003). The notion of the effectivity enables us to account for the fact that the same IT artifact (e.g., a laptop), can offer completely different possibilities for action (affordances) to one user – a novelist, and another user – a software developer; even though both may access the same physical properties of the artifact (e.g., screen, keyboard, trackpad) during the appropriation process.

As such, the effectivities concept can reasonably be used to extend the interaction model proposed by Markus and Silver (2008), providing a conceptual object for representing the individual characteristics of users and user groups which result in the creation of functional affordances for those groups with respect to a given technical object. This allows us to ask questions about both sides of the user/technical object pair to discover what creates novel affordances and, in turn, leads to innovative appropriations of IT.

### **System Representations**

Symbolic expressions, in Markus and Silver (2008), are messages concerning the system and how it may be interpreted and used. These messages may originate with designers, but they are not equivalent to designers' intentions. Problems during the system development process, marketing documentation,

public media and other information sources may also send messages about the system to users, some of which may conflict with designers' intentions (Perlroth, 2012). In addition, individual differences among users may result in multifinality in the effects of symbolic expressions: the effect of a marketing flyer, for example, may be contingent on a user's attitude to advertising.

To represent the user's picture of the system – the picture that may be shaped by symbolic expressions rather than the messages themselves – I propose the concept of System Representations. Davern et al. (2012a) use a similarly-named concept in their organizing framework for exploring research on cognition within IS, however my definition of the concept is more abstract. I define system representations as the mental representation of the system that is held at any given time by an individual user, or the shared mental representation of the system that is held by a user group. Unlike user perceptions – which are typically measured with self-report instruments and depend on users to reflectively assess and report their own mental states, system representations are conceptualized as embodying the full mental map of the system. Given extensive evidence from cognitive psychology that cognitive maps include elements that are not accessible to conscious awareness (Evans, 2008; Sloman, 1996), this implies that they cannot be directly measured using existing instruments. They must be retroactively inferred from what users actually do. This is significant, given the substantial evidence from previous research that self-reports often do not give a full and accurate picture of actual usage behaviors (Straub et al., 1995).

## **6.4 Affordance Field Theory**

In this section, I combine the above extensions to Markus and Silver (2008) and the new conceptualizations into an integrative framework that conceptualizes how users enact and identify appropriation moves. I take the common perspective in IS that using IT systems involves three fundamental conceptual objects: users, systems, and tasks (Burton-Jones & Straub, 2006; Pentland & Feldman, 2007). The conceptual framework shows how any interaction of these conceptual objects can be represented using an interaction model consisting of a set of objects, relationships, and actions. Figure 7 visualizes this model.

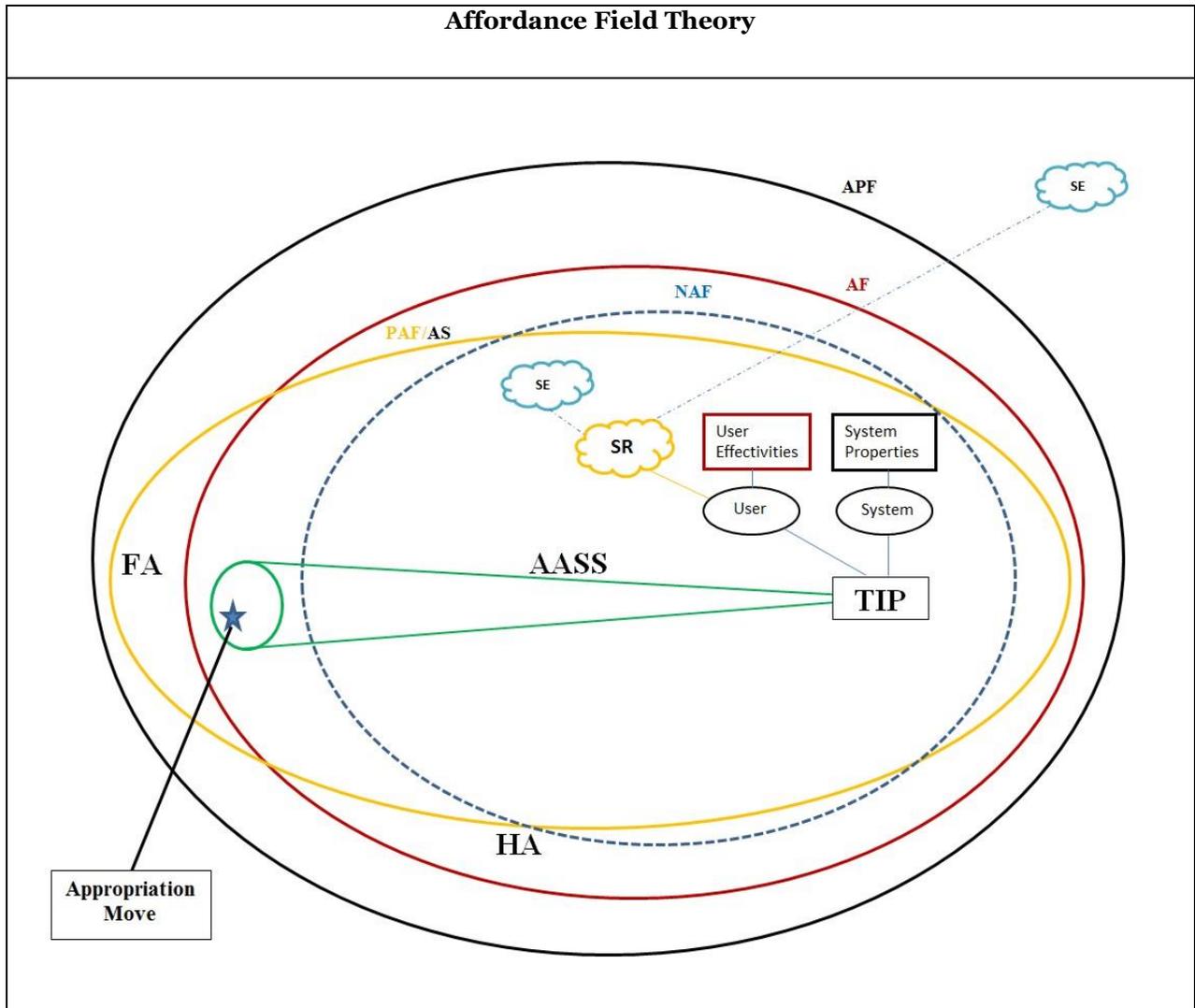


Figure 7: Affordance Field Theory Interaction Model

Table 3 provides definitions of the main constructs.

**Table 5: AFT Acronyms and Definitions**

<b>Objects</b>		
<b>Acronym</b>	<b>Name</b>	<b>Definition</b>
User	User	An individual or user group which appropriates the properties of a system in a goal-directed manner to perform a task
User Effectivities	User Effectivities	Properties and capabilities of the user which create affordances in combination with the properties of the system
System	System or Technical Object	IT artifacts and their component parts, as per (Markus & Silver, 2008)
System Properties	System Properties	Properties of the system which create action potentials.
SE	Symbolic Expressions	Messages that may be interpreted by the user concerning how a system is to be interpreted, and how it may be used
SR	System Representation	The full mental model of the system held by a user or user group
TIP	Technology in Practice	A sociotechnical object formed by the user and the technical object
APF	Action Potential Field	An area representing all possible affordances which may be created by the technical object
AF	Affordance Field	An area representing all available affordances created by the intersection of user effectivities and technical object properties
PAF	Perceived Affordance Field	An area representing all affordances which can be perceived by the user, given the user's system representation
NAF	Normative Affordance Field	An area representing the conventional range of affordances available to typical users of a system
<b>Actions</b>		
AP Move	Appropriation Move	A constructive use of a system that determines its nature and effect

AF Widening	Affordance Field Widening	A user's finding novel ways to apply existing properties of the system
AF Stretching	Affordance Field Stretching	A user's finding novel properties or novel way to apply the properties of the system
Overlap	Overlap	Incongruence among the different affordance fields which create effects
AASS	Available Affordance Space Search	The process of seeking and identifying available affordances carried out by a user
<b>Relationships</b>		
Convergence	Convergence	The degree to which the elements of the shared model of a system held by a user are common across members of a group. Represented by the degree to which the individual affordance fields intersect
Overlap		The degree to which the different types of affordance fields of a TIP are dissimilar.
FA	False Affordance	A type of overlap in which the perceived affordance field extends beyond the affordance field. Indicates that a user perceives an affordance which does not exist.
HA	Hidden Affordance	A type of overlap in which the affordance field extends beyond the perceived affordance field. Indicates that the user is not aware of an existing affordance.

To represent the main constructs, I borrow Gibson (1979)'s concept of a visual field as the context in which an affordance becomes available for perception. The background of the image visualizes a vast surface, which represents all the possible ways in which any technical object can be used – the domain of all possible action potentials or *tasks*. Within this domain, we conceive that the potentials for interaction between users and systems, and the accomplishment of tasks through that interaction, can be represented with a set of conceptual objects, relationships, and actions. These are defined as follows.

### 6.4.1 Conceptual Objects

#### *User*

In keeping with the specifications of Markus and Silver (2008, pp. 622, 628), I use the generic term “user” to define individual users or user groups. Users are defined on an ad-hoc basis depending on the scope of specific studies. Users have effectivities which may create action potentials in combination with the properties of technical objects, creating affordances. Users also evaluate and interpret symbolic expressions – messages about the system and the way in which it may be used – which may come from a number of sources, including direct interaction with the technical object. These interpretations lead to the user forming a mental model of the system (Bostrom, Olfman, & Sein, 1990), which, in common with previous researchers (Davern et al., 2012a), I define as a system representation.

### ***System***

A parsimonious way of saying “Technical Objects,” as per Markus and Silver (2008). As technical objects, systems have properties that can create action potentials which may be engaged to perform tasks. System properties may also be interpreted by users, and are thus one source of symbolic expressions. Symbolic expressions, in turn, can create System Representations, which represent the user’s cognitive model of the system. Note that systems themselves can be thought of as representations: representations of task domains (Burton-Jones & Grange, 2012; Burton-Jones & Straub, 2006).

### ***Technology-in-Practice (TIP)***

The effect that technical objects have on the world depends, in part, on their intrinsic nature – i.e., their properties; but also on the way in which they are actually used. Systems may intrinsically be capable of a variety of functional actions, but the actions that are selected, and the way those actions are implemented, by users is what determines their actual nature in a use context. For example, a computer program such as Microsoft Excel could be a tool for maintaining stock lists, designing forms, maintaining a simple budget, or performing complex quantitative modeling, depending on how it is used. Orlikowski proposed the concept of the “technology-in-practice”: a sociotechnical construct formed by the user and the system, whose nature is determined by the enactment process involved in its use (Orlikowski, 1999, 2000). I will adopt this concept.

### ***System Representation***

The available symbolic expressions regarding a system lead the user to create a mental model of the system and how it may be used. This mental model is the System Representation held by the user. The System Representation is fluid and may change as the user is exposed to information about the system. It should be noted that the Technology In Practice is formed by the properties of the system combined with the effectivities of the user; while the System Representation is formed by the user’s cognitive processing of symbolic expressions.

### ***Action Potential Field (APF)***

Some of the properties of a system may include capacities for actions that may be applied by users to interact with elements of the environment in order to produce outcomes that fulfill users' goals. Another way of saying this is that system properties create action potentials. The action potentials of any system are a subset of the action potentials created by all systems. Within the domain of action potentials, the action potentials created by the properties of a specified system form that system's Action Potential Field. In the AFT model, it is represented by an elliptical area representing the intersection of the system's properties with the domain of potential tasks to which any system could be applied. It represents all the possible ways in which the system may be used by any user.

### ***Affordance Field (AF)***

The user side of the TIP has effectivities which can combine with the properties of the artifact side of the TIP to create affordances. This range of affordances so created can be represented by an elliptical area which we name an Affordance Field. The affordance field represents all the tasks that a specified user can perform with the specified technical object. For most TIPs, the affordance field will always be a subset of the action potential field because no user is likely to have all the effectivities necessary to make use of all the action potentials offered by the system.

### ***Perceived Affordance Field***

While the affordance field is determined by the intersection of user effectivities and system properties, the user will not necessarily have perfect information about either of those conceptual objects. The user will become aware of the system's properties and develop a mental model of the system and how it can be used through symbolic expressions which may come from explicit information sources, or implicit meanings attached to symbols in the context. These symbolic expressions will lead the user to form a system representation that will determine what affordances are *perceived to be offered* by the system. The Perceived Affordance Field represents all the affordances which the user can perceive to exist, given her current system representation.

### ***Normative Affordance Field***

For any given technical object, there will be a range of uses which are conventional or 'standard', and some which are feasible, but unusual or unexpected. For example, a tablet computer may be used as an email client (normal), but may also be used as a file server (non-normal, but feasible). The range of conventional uses is represented by the Normative Affordance Field, which we define as area within the action potential field within which the user affordance field will commonly fall. The normative affordance field can be defined statistically, by measuring the typical use patterns of users, or inductively, by analysis of the symbolic expressions available to users.

## 6.4.2 Relationships

The relational concepts in AFT represent relationships between the conceptual objects that describe the *state* of the relationship at a given point in time between the conceptual objects above. I propose two types of relationship. *Overlap*, describes a type of relationship between the different types of affordance field. *Convergence* is specific to analysis of user *groups* and relates to the relationship between the members of the user group.

### ***Overlap***

Each of the different types of affordance field represents a different aspect of the relationship between the user and the system: an affordance field represents what the user is able to do with the system; a perceived affordance field represents what the user perceives that they are able to do with the system, and the normative affordance field represents the prevailing norm regarding how the system ought to be used. The potential differences in these concepts can be represented as the degree of overlap in the respective affordance fields of the model. For example, a specific user, when accessing the action potentials of a specific technical object, will have specific affordances. However, the user may perceive the existence of affordances which do not actually exist: e.g., the user may believe that the system offers a specific action potential when, in fact, it does not. This *false affordance* can be represented in the model as the perceived affordance field extending beyond the affordance field. In contrast, the user may fail to perceive an existing affordance – creating a *hidden affordance*. This can be represented by the perceived affordance field failing to cover part of the affordance field.

The different types of affordance fields are related, but independent, constructs. This means that their relationship to each other may differ over time in a sequential manner. For example, a user may have a goal that involves accomplishing a task outside of the action potential field. This would mean the user's perceived affordance field would stretch beyond her affordance field (by definition, an affordance field can never stretch beyond a system's action potential field). However, affordance fields are dynamic – making an appropriation move can distort the affordance field (e.g., making configuration changes to a system can change its capabilities and distort its affordance field). For the user, making a series of appropriation moves, each of which stretch the affordance field and the action potential field, may bring the task within the affordance field. The task would therefore be accomplished through making use of a serial affordance.

### ***Convergence***

Like Markus and Silver (2008), I intend the constructs in in affordance field theory to apply to specified users and user groups. As such, AFT objects, such as system representations, may be held by individuals, or shared across collectives. Other concepts, such as effectivities, may also be distributed among the individual members of collective user groups. In groups where objects such as representations are held by

multiple individuals, one characteristic of the group which may be considered is the degree to which each individual's representation is similar to the representations of other individuals within the group. Variations in this characteristic may result from factors such as member similarity and group cohesiveness, and may have various effects on the effects and outcomes associated with the group. Shared objects such as representations may be, in part, a product of the individual representations held by members of a group, but they may also be emergent from group processes. The variability in the similarity and cohesiveness of shared representations and distributed mental models may be expressed by the concept of *convergence*. Convergence is defined as the degree to which shared informational representations of conceptual objects in a group are common across members of the group. Convergence varies along a continuum from *tightly converged* to *loosely converged* based on the degree of commonality in the representation held across the group. It can be visualized by reference to the model of the affordance field:

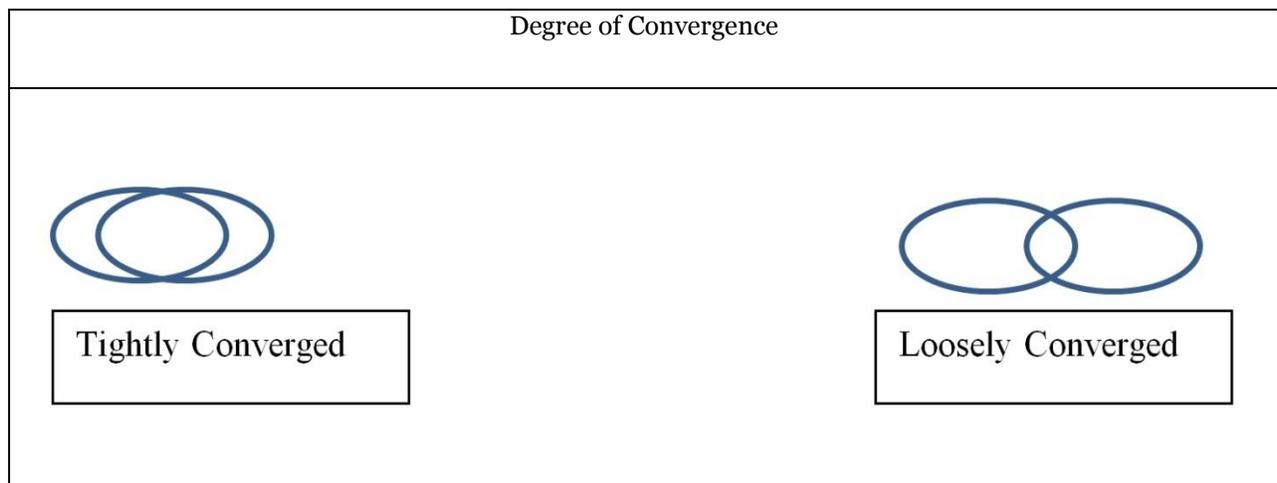


Figure 8: Degree of Convergence

In this model, the degree of convergence can be represented by the degree to which the elliptical areas representing individual affordance fields intersect.

Affordance field theory provides a representational scheme to depict levels of convergence for specified concepts within specified groups, but does not predict causal relationships between degrees of convergence and outcomes or effects. This allows it to be used by researchers employing different assumptions about the specific effects of levels and types of convergence, and effects which may be unexpected, and nonlinear in nature (Uzzi & Spiro, 2005).

### 6.4.3 Actions

#### *Appropriation Moves*

In AFT, the concept of appropriation is conceptualized in a way largely similar to the way it is defined in the original formulation of adaptive structuration theory (DeSanctis & Poole, 1994). Appropriation references the fact that the way an object is used is key to determining the nature of the object: a hammer can be a tool, a weapon, or a symbol; depending on how it is used. As such, the intrinsic nature of a system is not determined simply by its properties, and the same system (object) can be a different thing in different contexts (Poole & DeSanctis, 1989).

Appropriation is fundamentally similar in both DeSanctis and Poole (1994)'s and Markus and Silver (2008)'s versions of adaptive structuration theory, but it also has important differences. DeSanctis and Poole saw the structures within the technology as being enacted by users through appropriation moves, which involved:

- a) Making choices about how to use technology structures
- b) Choosing to appropriate technology features faithfully – in a manner consistent with the spirit of the system and the design of the features; or unfaithfully – out of line with the system spirit
- c) Selecting different instrumental uses for the technology, and
- d) Displaying different attitudes as the technology structures are appropriated.

When the fundamental concepts of structural features and spirit are replaced, as was done by Markus and Silver (2008), it is obvious that the processes inherent to the making of appropriation moves must also be reconceptualized. The action concepts discussed below form a framework for analyzing the action “behind” appropriation moves in AFT.

### ***Affordance Field Widening***

Affordance fields are dynamic objects, in that changes to the elements that determine the area of the field will result in changes to the corresponding field. For example, changing a user's effectivities through training, for example, may change the user's affordance field. Changing the way a user interprets system properties by exposing the user to analogues (Bostrom et al., 1990) may change her perceived affordance field, etc. It is proposed that affordance fields can be changed by being distorted in two orthogonal axes: they can be widened, or stretched. It is theoretically possible for an affordance field to be contracted, rather than expanded: for example, the user of a system that permits two-handed operation may have a contracted affordance field if she breaks a hand. However, the circumstances in which AF Contraction would occur are likely rare. For such situations, I believe that representing such distortions as *negative* widening or stretching would be appropriate.

In affordance field widening novel ways of applying existing properties of the system are developed or discovered by the user. This includes applying known properties in new ways or transferring their application to novel problem domains.

The fundamental activity involved in AF widening is *analogic transfer*.

### ***Affordance Field Stretching***

In addition to the discovery of new ways to apply existing properties of systems, users may also discover or develop completely new properties or application methods. For example, a user may make use of an application programming interface or macro facility provided by the system to extend its capabilities – thus creating new action potentials. This is represented in the AFT model by affordance field stretching.

The fundamental activity involved in AF stretching is *generative production*.

### ***Available Affordance Space Search***

The appropriation of a system by a user is typically a goal-directed activity (Burton-Jones & Straub, 2006, p. 231). In this context, I define a *goal* as do Fishbach and Ferguson (2007, p. 491): “*a cognitive representation of a desired endpoint that impacts evaluations, emotions and behaviors*”. When users have goals that they perceive can be accomplished by the application of properties of a system, they seek ways to apply those properties. The general way of representing the search for a problem solution is that an intelligent system (typically, a human) traverses a “problem space” (M. Perry, 2003, p. 195): an abstract representation of the goal state that is being sought and the possible routes to that state (Boland, Goraya, Berente, & Hansen, 2009). I propose that the search for an appropriation move that is possible (i.e., within the Perceived Affordance Field) and will result in the attainment of the desired goal state represents a traverse of a problem space by the user. The problem space they traverse is that of the available affordances offered by the system, which I define as the *Affordance Space*. When they identify available affordances created by their own effectivities and the properties of the system, they make suitable appropriation moves based on that perception. This can be represented as a search of the Affordance Space offered by the system.

Users will typically search for affordances that correspond to their effectivities, rather than seek action potentials which are not available to them. For example, if a user with no programming skills is seeking to use a system which exposes an API, the user will typically search for ways to use properties which they do have the skills to exploit, rather than seek properties which they cannot use. In other words, users seek affordances which are available to them. The user will therefore conduct an available affordance space search to identify exploitable affordances which match their goals. It is worth noting that, in the case of user groups, different members of the group may have different effectivities (e.g., one member may have domain expertise, and another, programming skills). In this case, the group’s available affordance space will represent the sum of the affordances created by individual members’ effectivities, as well as any group network effects.

## 6.5 Applying AFT

The above descriptions may appear to represent the making of appropriation moves as a single-step process. In the real world, this is often not the case. Appropriation moves may involve multiple steps, including failed attempts, satisficing, unforeseen consequences, etc., etc. Affordance Field Theory attempts to standardize the way the steps are represented. For example, a user may conceive a goal (Fishbach & Ferguson, 2007), which is outside of the current Affordance Field, and pursue it by making use of serial affordances to stretch the affordance field. This is not only a highly condensed representation of the process of system development, in which existing tools and components are used to build a new system, but is also the activity that people are often involved in when they “implement” a system. However, this kind of behavior is not limited to the development or implementation of systems. People develop goal states and pursue them through modifying the way they use systems at various points in the system lifecycle. In the course of doing so, they engage in cycles of ideation and enactment that move them toward that goal state. AFT provides a set of standard conceptual categories for events that occur in those cycles.

The stated goal of Markus and Silver (2008) was enabling researchers to construct better hypotheses. The goal of AFT is broader: to enable researchers to *ask better questions*. By representing the full problem space of user interaction with IT, it facilitates a range of questions that go beyond the scope of traditional hypotheses.

## 6.6 An Illustrative Case

To illustrate how AFT concepts were applied in order to analyze the case data, it may be useful to return to one of the “Creative Incident” cases from chapter 5, and show how the events in the case can be theoretically redescribed using AFT. Below is a copy of the description of the “Order Book” case from organization Beta:

Several years after the initial development of the Product system, the founders of Beta decided that the company had outgrown their own style of leadership, and needed professional management. They hired a team of professional managers which included a CEO, and an IT manager, who I will call RR. The hiring of the new executives was part of an effort by the founders to formalize their internal processes and increase efficiency, since rapid growth in their order volumes was making a number of business processes more difficult to manage. One particularly difficult process was communicating with customers about what types of widgets they wanted to buy, and in what quantities. Beta would receive relatively small orders for each line of widgets from each customer. When the orders were collated, they would then decide which lines of widgets could be economically manufactured,

given the total number of orders. Several lines would typically be dropped at that point in the process, and the prices of some lines would have to be adjusted in order to make them profitable. The adjusted catalogue would then go out again to customers to enable them to make necessary changes to their orders based on the adjustments that had been made.

All the communication necessary to manage this process had traditionally been done using a large, printed order book, copies of which were physically distributed to the customers. As the volume of orders increased, this system became increasingly untenable. Small errors, such as differences between the product codes in the order book and those in the company's internal inventory management system, would mean time-consuming delays and frustrated orders by customers. In addition to the inefficiencies created by errors, the sheer volume of work required to run the manual system was making it impossible meet production deadlines. The merchandise manager, who I will call AN, discussed the situation with the new IT manager, RR. AN and RR agreed that there was a need to improve the efficiency of the ordering process, while maintaining the configurability and verifiability of the manual process. RR had several meetings with the marketing and customer relations staff, then went away to develop a solution.

RR designed a system which automated the ordering process using an electronic file generated by Product. The information that had previously been sent to customers in the paper order book was transferred into Product, and was sent to customers via email. Email made it easier to manage the communications with customers, and the files from these orders were returned to the IT manager after they had been filled out by customers. Information from their finalized order files (in Product) was then typed into Beta's ERP package for order processing. The IT manager became deeply involved in each step of the ordering process. The production of the electronic file with the order options for widgets was done by RR, who was also responsible for uploading the finalized order files to the ERP.

A few years after this system had been put into effect, the IT manager that had replaced the paper order book with a Product file resigned, and MC – the current IT manager – was hired to take her place. MC was highly dissatisfied with the large amount of manual processing that was involved in the processing of customer orders. MC had significant experience as a software engineer, and spent the first three weeks on the job automating the process of creating the Product order book. His initial goal was to reduce errors: the (then) current system made it possible to type in combinations of options for widgets that were not actually available, and a lot of time was spent dealing with data entry errors on the part of Beta and/or its customers. He also wished to move responsibility for the ordering process to the sales department, which was formally responsible for it. He then designed an

intermediary system which would automatically “scrape” order configurations from the completed Product order files and load them into the ERP. He also designed automated reports that enabled the sales department to accomplish much of the checking and verification that had previously been done by RR. This arrangement makes his involvement in the actual ordering process minimal.

This account could be broken down into the following core events and descriptions:

**Table 6: Example Descriptions of Events in Beta Case**

<b>Event</b>	<b>Description</b>
RR joins the staff at Beta	RR is an experienced IT manager and is hired because of her corporate background. She sees her main duties as helping to change the organizational culture at Beta, and improving the efficiency of the firm’s operations.
RR is familiarized with the systems in place at Beta	As part of her induction to her duties at Beta, RR becomes familiar with all the systems which are used in their operations in different departments
AN and RR meet to discuss the problems being experienced with the manual system for processing customer orders	In light of RR’s mandate to improve efficiency, AN asks her to find a way to improve one of Beta’s key business processes: collecting customer orders
RR develops a solution to the problems which involves using the features of Product	RR recognizes a similarity between the problems that the production department had solved using the features of Product, and the problem that was now faced by the customer service department. She develops a solution based on Product that is similar to the one developed by the production department. This solution achieves two goals: it improves the efficiency of the process, and it puts her at the center of one of the firm’s most critical business processes, where she is able to influence a change in culture
MC joins the staff at Beta	MC is an experienced software engineer and is hired because of his expertise with the technical systems being used by Beta. His main goals are improving the reliability and efficiency of Beta’s IT systems, and fixing a culture of excessive dependence on the IT staff to perform line operations among the users, which he sees as unsustainable
MC modifies the Product-based system to reduce manual operations and automate	MC makes modifications to the ordering system that reduces the need for manual data entry, and creates tools that allow the sales staff to manage most of the process of soliciting and processing customer orders. This solution achieves two goals: it improves the reliability and efficiency of the ordering system, and it allows the end users to take

several processing steps	control of the ordering process, reducing the involvement of IT staff.
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This set of events can be theoretically redescribed using AFT constructs (with the construct type in parentheses), as follows:

**Table 7: Example Re-description of Events in Beta Case**

<b>Event</b>	<b>Re-Description</b>
RR joins the staff at Beta	RR brings a number of <b>Symbolic Expressions (object)</b> from her prior training in IT and her corporate background. Her major goals are helping to change the organizational culture at Beta, and improving the efficiency of the firm's operations.
RR is familiarized with the systems in place at Beta	As part of her induction to her duties at Beta, RR develops <b>System Representations (object)</b> of the all the <b>Systems (object)</b> at Beta. She develops <b>Perceived Affordance Fields (object)</b> for each <b>System (object)</b> and begins an <b>Available Affordance Space Search (action)</b> for <b>Appropriation Moves (action)</b> which can accomplish her goals
AN and RR meet to discuss the problems being experienced with the manual system for processing customer orders	In light of RR's mandate to improve efficiency, AN asks her to find a way to improve one of Beta's key business processes: collecting customer orders
RR develops a solution to the problems which involves using the features of Product	Because of <b>Symbolic Expressions</b> from seeing what the production department has done with Product, RR's <b>Perceived Affordance Field</b> for Product is <b>Widened (action)</b> beyond the <b>Normative Affordance Field (object)</b> of the <b>System</b> . Due to <b>PAF Widening</b> RR identifies an <b>Appropriation Move</b> which involves using Product as a communication system, just as the production department did. Utilizing <b>Effectivities (object)</b> from her training and background, she uses <b>Action Potentials (object)</b> offered by the properties of Product and makes the <b>AP Move</b> . Doing so accomplishes her two major goals.
MC joins the staff at Beta	MC is an experienced software engineer and is hired because of his expertise with the technical systems being used by Beta. Because of different <b>Symbolic Expressions</b> that he has got from his own background, he develops different goals from RR and begins an <b>Available Affordance Space Search</b> for <b>AP Moves</b> which can accomplish his goals

<p>MC modifies the Product-based system to reduce manual operations and automate several processing steps</p>	<p>MC develops goals which are outside the <b>Affordance Field</b> of the <b>System</b> created by RR, such as reducing manual entry, and giving sales staff control of the ordering process. Utilizing <b>Effectivities</b> from his background as a software developer, MC makes use of <b>Serial Affordances (object)</b> offered by APIs in Product. He is able to <b>Stretch the Affordance Field (action)</b> of Product until the <b>AP Moves</b> that accomplish his goals are within the <b>Affordance Field (object)</b>.</p>
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It should be noted that the statements in the above descriptions of the events are based on conclusions formed by analyzing the case data. As has been noted previously, some of these conclusions are subject to the multifinality inherent in the critical realist Open Systems Perspective (Wynn & Williams, 2012). As such, there may be multiple possible explanations for an event, and the researcher must employ judgment rationality to reach a conclusion. However the test of AFT is not whether it can “prove” any single explanation or description of an event – given the limits of the available data, that would not be possible. Rather, the test of AFT is whether it can theoretically redescribe any explanation that has been generated through judgment rationality. AFT meets this test.

For example, the re-description of the fifth event in Table 7 gives the following AFT-coded description of the event:

Because of **Symbolic Expressions** from seeing what the production department has done with Product, RR’s **Perceived Affordance Field** for Product is **Widened** beyond the **Normative Affordance Field** of the **System**. Due to **PAF Widening** RR identifies an **Appropriation Move** which involves using Product as a communication system, just as the production department did. Utilizing **Effectivities** from her training and background, she uses **Action Potentials** offered by the properties of Product and makes the **AP Move**. Doing so accomplishes her two major goals.

What if, on collecting further data, it was decided that it would be more accurate to say that RR was not influenced by what the production department did, and generated the idea to re-purpose Product on her own? The description could be rewritten:

Because of **Symbolic Expressions** from her background and training, RR was able to **Stretch her Perceived Affordance Field** for Product beyond the **Normative Affordance Field** for the **System**. Due to **PAF Stretching** RR identifies an **Appropriation Move** which involves using Product as a communication system. Utilizing **Effectivities** from her training and background, she uses **Action Potentials** offered by the properties of Product and makes the **AP Move**. Doing so accomplishes her two major goals.

AFT is therefore able to function as a descriptive theory, and is not tied to any particular interpretation of the data.

It should also be noted that at a more (or less) atomistic level of analysis there would be a different number of events, moves, etc. The critical realist principle of Emergence (Wynn & Williams, 2012) is applied to analyze events at a certain level of detail.

## **6.7 Limitations of AFT**

It should be noted that AFT provides a way to represent the cycles of ideation and enactment that are involved in developing novel appropriation method effectively. As such, it is useful for studies investigating contexts in which this kind of behavior is important. AFT is a useful tool for asking how and why questions about how systems come to be appropriated in certain ways. AFT also provides a useful tool for comparing appropriation behaviors across contexts in multiple-case studies or research programs

AFT is less effective when the focus of a study is on measuring the extent of use, especially when such extents are best represented as quantities, frequencies, or making comparisons about productivity or efficiency. For such research problems, methods for measuring use such as the procedure developed by Burton-Jones and Straub (2006) may be more appropriate.

Another limitation of AFT is its use of spatial metaphors and language to describe individual and distributed cognitive processes. Boland (2001) has discussed the confusion created by the human tendency to use a primarily spatial vocabulary to describe cognition and behavior, which unfold as temporal processes. There is room for further development of AFT to more realistically represent the time dimension of cognitive processes.

## **6.8 Discussion of AFT**

It must be acknowledged that AFT contributes to an ongoing, and sometimes contentious, discussion about how cognitive and behavioral processes should be represented in research. From a social cognitive perspective, shared cognitive structures representing environments and tasks in organizations have been captured in concepts such as Orlikowski and Gash (1994)'s "Frames". However, Gal and Berente (2008) have argued that temporally bounded, technologically centered and individually-focused models of cognition such as frames offer superficial explanations for IS phenomena, and argue for a social representations theory approach. However, these arguments occur at the "representation and algorithm" level of Marr (1982)'s hierarchy of abstraction, rather than the "computational theory" level. AFT does not presuppose a representational scheme and is not incompatible with either approach. AFT could, for example, be used to frame questions about the efficacy of different representational models for cognitive processes.

As was noted in chapter 2, the IS discipline has recently seen a number of new models proposed for representing the interaction of users with IT systems (Germonprez et al., 2011; Leonardi, 2011; Orlikowski, 2007). As another new model, AFT can make claim to the following merits:

- Represents the full problem space of user interaction with IT, having conceptual objects to represent the user, the system and the task
- Enables the representation of the flows of information and other influences that shape user behavior – in the form of SEs
- Enables consideration of the potential, as well as actual, appropriation behaviors that users engage in
- Provides a common language (Benbasat & Zmud, 1999) for analyzing user behaviors across contexts – even in intensive research

However, it also has the following limitations

- Does not represent repetitive, common units of use as well as some competing representational schemes
- Limited representation of contextual detail.
- For research contexts where measurement of efficiency in performing repetitive tasks is important, other representational strategies such as that proposed by Burton-Jones and Straub (2006) may be more effective

As such, AFT provides another tool for researchers involved in the study of change and ideation events in IS research. It may be particularly useful in multiple-case studies, in which findings from different case contexts must be integrated. It may also be used in multi-method research programs. The objects, actions and relationships of AFT may be operationalized in a number of ways and can be useful for asking *what*, *how* and *why* questions. It may even be used to represent aggregate findings across studies, providing a common language for different researchers looking at similar problems (Benbasat & Zmud, 1999).

All told, AFT represents a significant contribution to the ongoing discussion in the literature about how the utilization of information systems by users should be represented. It is one of the major contributions of the study.

## **6.9 Within-Case Analysis**

The analysis of data in this study can usefully be looked at using Eisenhardt (1989a)'s categories of within-case and cross-case analysis. In this section, I summarize the within-case analysis conducted. The analysis begins with the a priori codes based on the work of Amabile. However, as the coding scheme was changed

(along with the design of the study, as permitted in Eisenhardt (1989a)'s method), AFT is used to theoretically redescribe the data.

The following section summarizes the within-case analysis undertaken in each of the five cases that were theoretically selected before saturation dictated the termination of the analysis.

### **6.9.1 First-Cycle Coding**

In this phase of the analysis the recorded interviews were transcribed and the interview media files, along with the transcripts, were loaded into NVivo. The transcripts were coded and then first cycle coding (Saldaña, 2009) was done, initially using the a priori codes from the work of Amabile (Amabile, 1983, 1988, 1996). This phase of the work also served to deepen familiarity with the data, and assist in developing the overall analytical strategy. The initial coding and analysis was done in parallel with the data collection, and, as recommended in (Eisenhardt, 1989a), and consistent with (Calderwood, Crandall, & Klein, 1987; G. A. Klein et al., 1989), minor changes were made to the case study protocol in response to learning during the study. For example, the Time Line Verification and Decision Point Identification step from the full Critical Decision Method had been dropped (Crandall et al., 1998, p. 16). However, during data collection I found that assisting me in constructing a timeline often prodded participants to correct temporal order confusion in their initial accounts of the incidents. In response to this, I included an abbreviated timeline construction exercise in the interviews.

### **6.9.2 Narrative Networks**

Narrative networks were constructed using the guidelines of Pentland and Feldman (2007). The narrative networks were constructed by analytically combining all the evidence in each case: typically multiple interviews, as well as email transcripts, public documentation, website change logs, annual reports, software samples, and observations. The construction of the narrative networks was a primary analytical step in the research process, as it involved analytically reducing the data, resolving conflicts between data sources, and selecting which events were judged to be part of the “core story” (Pentland & Feldman, 2007, p. 782) in the narrative.

After the narrative networks were constructed, they were then coded with AFT constructs. Each node in the narrative net (which represents an *action*: two or more actants and an action that connects them), was theoretically redescribed (Wynn & Williams, 2012, p. 796) using objects, actions and relationships from AFT.

This makes the actions in the nodes more easily comparable to facilitate the retroductive analysis.

## 6.10 Cross-Case Analysis

The following sections summarize the cross-case analyses conducted during the study. It should be emphasized that the analyses described in these and the preceding sections are done iteratively in parallel (Wynn & Williams, 2012, p. 796), but are described serially.

### 6.10.1 Refining the Research Question

As discussed in the section on CR methodology in Chapter 3, a critical part of structural analysis is deciding which *type* of mechanism is being studied. Since there are typically a near-infinite variety of structural entities involved in any real-world research context, it is necessary to determine which structures are *causally relevant* (Wynn & Williams, 2012, p. 798).

In this study, as I analyzed the data from the cases, it became clear that the driving force behind incidents of user creativity lay in decisions made by participants in those incidents. Users decided to change the way that they used the systems they interacted with. The centrality of decision-making in case studies has been noted by Yin (2009). This meant that I needed to look at the processes that led to the decisions that participants in the cases had made, and the actions that they took as a result of those decisions. As I did so, I found patterns in the data, both within and across cases, that could be explained by dual-process theories of reasoning and judgment. I also realized that I was seeing patterns of action at the collective level which paralleled actions which might be explained by theories of reasoning at the individual level. Finally, although I did not change the scope of the study, I realized it would be impractical, and misleading, to try to explain the actions of individuals without describing the environmental and social contexts in which they were making decisions.

These realizations were used to determine the analytical strategy followed in the study, as prescribed by Eisenhardt (1989a). I adopted cognitive science as an overarching lens, and selected dual-process theory as an analytical lens. I selected distributed cognition as a way of extending the analysis of cognitive processes beyond individual users and out to the groups and collectives of which they were a part and with which they collaborated. I selected a cognitive task analysis technique that had been applied in studies of decision-making – the Critical Decision Method – as a data collection instrument. I selected two analytical tools that were suitable for analyzing what people do, and the cognitive inputs to their actions: narrative networks and framework matrices. Finally, I refined the research question further, to reflect the clarification of the scope of the study. The refined RQ is:

- *What are the cognitive mechanisms that explain end user creativity in the appropriation of Information Systems at the individual level?*

### **6.10.2 Retroductive Analysis**

The retroductive analysis was carried out following the guidelines of Wynn and Williams (2012). For each node of the narrative network that had been constructed and coded using AFT constructs, I applied the retroductive question: *What cognitive mechanism must exist in order for the observed action to have been taken?*

The primary analytical tool employed was multiple thought trials, following (Weick, 1989). Thought trials were conducted to hypothesize the existence of cognitive mechanisms that could explain the actions observed in each node of the narrative networks. Candidate mechanisms were applied to the node, then to other nodes in the data. Where a mechanism *M* could explain the action in a node it was preserved. If it could not explain the action in a subsequent node, a new mechanism *N* was developed for that node. If a subsequent action could be explained by *M*, then the node was coded to *M*. If the second node did not quite fit *M*, but could be explained by a modified version *Ma*, then *M* was modified to *Ma* if *Ma* could also explain the original node coded to *M*. The fact that all the actions in each node were coded in AFT constructs facilitated the application of mechanisms across nodes.

This process continued until all nodes in all narrative networks had been explained by hypothesized mechanisms. As a test of the comprehensiveness of the set of mechanisms, the narrative networks, which had been coded with AFT, were recoded with the identified mechanisms. One test of the adequacy of the set of mechanisms that had been identified was the ability of those mechanisms to code each node in each narrative network.

The scope of the thesis required that the mechanisms not only describe but also explain the creative appropriation of IS by end users – at the individual level. In order for the mechanisms to provide an explanation, it was necessary to show how they work together as a system. A model that integrates all the identified mechanisms and shows how they explain creative appropriation at the individual level was developed. This model will be introduced in the following chapter.

### **6.10.3 Second Cycle Coding**

As per Saldaña (2009), a second cycle of coding was done to the raw data. In this cycle, the mechanisms identified in the retroductive analysis were used to directly code the data. Data points that illustrated the activation of a particular mechanism were coded to that mechanism. All coding was done within NVivo.

The CR principle of multifinality implies that a visible outcome may be the result of more than one mechanism – that is, there are situations in which there are multiple possible explanations for an outcome. In situations within the data where there was some ambiguity about mechanism which caused an outcome, *judgment rationality* was applied to find the mechanism which provided the best

explanation of the outcome (Wynn & Williams, 2012, p. 795). This kind of application of judgment is a common necessity when working with unobservable mechanisms. It is justified in this study by the fact that the goal of the study is not to precisely enumerate all the mechanisms working in each case (which, given the limitations of the available data, is likely not possible). It is rather to identify a set of mechanisms which can explain the outcomes observed in each case.

It should be noted that there is no expectation that there should be a symmetry between the coding of the narrative networks and the coding of the data. The narrative networks are an analytical reduction of the case data, and there is therefore no direct correspondence between points in the raw data and nodes in the narrative networks.

#### **6.10.4 Framework Matrices**

For empirical corroboration of the mechanisms, framework matrices were run on the recoded case data using NVivo software tool (Ritchie & Spencer, 2002). The framework matrix tool generated matrix charts of the coded data. The final charts were 5 x 9:

- 5 cases:
  - Beta case 1
  - Beta case 2
  - Gamma case 1
  - Alpha case
  - Zeta case
- The data was coded to:
  - Simulation (for simulation outputs)
  - D. Cog (for distributed cognitive operations)
  - And seven cognitive mechanisms (listed in the following chapter)

The framework matrices represent a form of thematic analysis (Braun & Clarke, 2006), in contrast to the narrative networks which are a processual tool. The complementary logical forms of the tools provide confidence in the explanatory power of the mechanisms (Wynn & Williams, 2012, p. 801). While, there is no expectation of symmetry across the analyses, the test is that each kind of explanation makes sense: that is, shows causal depth and sufficient explanation of reality (Wynn & Williams, 2012, p. 801).

#### **6.11 Natural Experiments**

Yin (2009) (on whose methodology Eisenhardt (1989a) is partially based) recommends the use of experimental logic to make comparisons and tease out patterns in case data. In the data in this study there are two patterns which created opportunities to use experimental logic.

One of these patterns is the conflicting usage patterns of the two systems at organization Phi. In Phi, the users of the system Process exhibited a tendency to constantly find ways to appropriate the system that, even though they were not formally evaluated by raters, seem to meet the study's creativity criterion: they were novel, useful, and surprised the developer of the system (the developer and administrator of Process was one of my primary interviewees at Phi). On the other hand the staff of the Finance department, who had similar skills and also had a system that did not conform to their needs, did not creatively appropriate the system on any occasion.

Likewise, at another level of analysis, it is possible to look at the pattern in the cases overall. That is, the conditions at the negative case organizations (Theta and Kappa), can be compared with the conditions at the organizations in which cases of creative appropriation were found and investigated<sup>2</sup> (Alpha, Beta (2 cases), Gamma (2 cases, 1 investigated), Zeta, and Phi (the Process cases)). The primary observation from comparisons across these cases is this: creative appropriation tends to NOT occur in a 'natural progression' of use becoming more sophisticated. This contradicts what may be expected from the work of Saga and Zmud (1993), Jaspersen et al. (2005), and other popular stage theories of how novel use patterns should evolve. Instead, creative appropriation seems to be driven by *loss avoidance*. The losses can be process losses (e.g., Beta not being able to keep up with expanding business demand while using their fax-based communication system), or actual losses (e.g., Alpha losing access to their regular software solution for handling project reports). Users will typically make use of other resources for avoiding process losses before resorting to creative appropriation – as was observed in the Finance department at Phi.

The mechanism-based explanation should address why this pattern is observed – i.e., it should explain the findings from the quasi-experiments. The mechanisms that explain this pattern will be described in the following chapter.

## 6.12 Theoretical Saturation

Saturation was determined to have been reached under the following circumstances.

Of the 18 potential cases of creative appropriation identified, five had been investigated and analyzed in detail. It had been previously been decided that mechanisms would be required to be *confirmed*: that is, seen to be active in more than one case. There was no a priori assumption that evidence of every mechanism would be observed in every case; but it was decided that no mechanism would be accepted if there was only evidence for its existence and action in a single case.

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<sup>2</sup> Although a number of incidents in which systems were appropriated in new and useful ways were discovered during field research, only the ones which were part of the formal rating exercise are being counted as "creative" for the analysis.

In the actual analysis, evidence for each mechanism identified was observed in each of the cases that underwent a detailed examination (i.e., had a narrative network and framework matrix constructed). Further, in each (detailed) case, all the case data (narrative network nodes, framework matrix blocks) was fully explained using the identified mechanisms. Also, no additional mechanisms were uncovered over the last two cases investigated (Gamma and Phi), and no modifications to the integrative model were made to accommodate patterns in those cases.

It was therefore determined that theoretical saturation had been accomplished after the five cases listed earlier were analyzed.

## Chapter 7. Findings

*All models are wrong, but some are useful*

*George Box*

### 7.1 Creativity - a complex outcome

The mechanisms identified in this study constitute a parsimonious model for explaining the cognitive information processing activities that occur during incidents of user creativity. The mechanisms described here summarize a set of patterns that seem common in successful events of creative appropriation. They do not guarantee it will happen, but they tend to explain events when applied retrospectively to the data. Hedström and Ylikoski (2010) note that mechanisms are inherently hierarchical in nature; and that individual mechanisms may be modified adaptations, or representations, of more abstract *mechanism schemes*. They may themselves contain components which are mechanisms at a less abstract level. They note that an explanation of a mechanism is not required to explain all the other mechanisms that it may be connected with at other levels. Nonetheless, in this analysis, I will describe a set of mechanisms, I will describe the mechanism schemes that some of the mechanisms appear to be types of, then I will integrate the mechanisms in order to describe how they work together as a system. This “system of mechanisms” can be seen as a mechanism itself, of which the component mechanisms are part, which means I will describe mechanisms at three levels of abstraction.

This full model – including the mechanism schemes, the mechanisms themselves and the integrative model – is not a process model in the strict sense. It does not describe a “creative process” which has a well-defined beginning, middle, and end. Rather, it describes a set of information transformations which are iterative and continuous. The integration of the individual mechanisms describe a *system*, it can be visualized as being like an electrical circuit. The circuit starts and initiates a particular set of information processing operations which will be described. These operations continue until the creative appropriation process ends. The flow of information through the system is cyclic, rather than serial. Nonetheless, the characteristics of mechanisms – like gates in a circuit – shape how the overall system functions. It is a creative system, rather than a creative process.

The overall system constitutes a means for explaining the actions which take place during, and are causally effective in, incidents of creative appropriation. As such, it is a Type II theory, according to the typology of Gregor (2006). The components of this theory are described below. I will begin by describing the conventions I will follow in reporting the findings.

## 7.2 Explanation by Cognitive Mechanisms

Decisions about the beginning and end points of cases, primary foci, etc., are always, to some extent, an analytical decision on the part of the researcher, rather than something that is obviously inherent in the world (Leonardi, 2011, p. 155). This is an inherent feature of some types of case studies (Yin, 2009). For example, in the Gamma case, several different organizations, and several different systems; each organization with a different mission, and each system with a different intended purpose; were brought together. They were brought together in an integrated way to develop something new that would serve Gamma's unique interests. Any or all of these systems could have been selected as the key focal artifact, but one (mobile phones) has been chosen for clarity and focus. The reason for this is that the case data is being used primarily to demonstrate the existence and causal depth of mechanisms, rather than to present the viewpoint of any particular actor or investigate the facts of any particular case. Therefore, the focus is on the underlying causal mechanisms at work in each case, rather than the detailed nature of the cases themselves

Each mechanism will be described in text and diagrammatic form. The text description of the mechanisms will be accompanied by a diagrammatic representation of the *logical form* of the mechanism: showing how the structural elements – the information structures and transforms – that make up the mechanisms relate to each other. Two forms of evidence will be given for each mechanism observed. The first form will be evidence of the operation of the mechanism at work in at least two of the detailed cases. Evidence from the quasi-experiments, including the negative cases, will be used to support the operation of the mechanisms and gain further contextual evidence about their enabling, stimulus, releasing, or constraining conditions (Wynn & Williams, 2012, p. 794). However the description of the mechanism will provide examples of the mechanism in action. The second form of evidence will be from literature: examples of phenomena which are explained by the mechanism at one or more of the levels at which it operates. The evidence from the literature will be followed by a diagrammatic representation of the *functional logic* of the mechanism. This will describe what the mechanism does, and the logic of the strategy it uses to do it (Marr, 1982). Where necessary, the operations of the mechanisms will be described at different levels of cognition.

It should be reiterated at this point that the fact that multifinality and equifinality apply to the activation of mechanisms make it difficult to map from particular events to particular mechanisms without some ambiguity. The same event can sometimes be modeled as the outcome of different mechanisms. Therefore, the goal of the analysis is not to prove that particular configurations of mechanism activation did occur – given the lack of direct observation and direct access to mental processes, that would in many cases be impossible. The goal of the analysis is, rather, to demonstrate that the identified mechanisms can explain the events observed.

Mechanisms, being typically directly unobservable, must be treated in much the same way that hypotheses are treated in hypothesis-testing research (Wynn & Williams, 2012). They can never be ‘proved’, but must be rigorously compared to other possible explanations and to existing evidence, until they are acceptable as explanations for observed events (Hedström & Ylikoski, 2010). The mechanisms here are proposed to be cognitive in nature. Each is based on direct observations in the case data. However, since each mechanism represents a cognitive operation, it is logical to expect that evidence should exist in the literature on cognitive processes which supports the existence and operation of that mechanism. This should hold, unless the mechanism in question has never been observed before.

For the mechanisms I will describe, there is considerable evidence that they exist and have been observed previously. There is a wealth of research on mental processes in the literatures on decision making, reasoning, judgment and social cognition (Evans, 2008; Kahneman, 2011; Morewedge & Kahneman, 2010; Stanovich, 2011), exploring how dual-process theory can explain experimental and field-based research findings in those domains. The operations represented by the mechanisms identified in this study are explained in that research, and so findings from those domains can be used as corroborating evidence for the existence of the mechanisms I propose. Incidentally, this supports the business-as-usual hypothesis of creativity, which states that creativity and intuition emerge from everyday mental processes, rather than an exclusive set of ‘creative-only’ processes (R.K. Sawyer, 2012; Weisberg, 1995).

The full set of mechanisms identified is listed below. For each mechanism, evidence will be provided to support it at the individual cognitive level, and examples will show how it may function at the organizational level.

### **7.3 Structural Components**

Mechanisms are structures, which have capacities for action (powers), and typical actions (tendencies). The mechanisms being described are constituted by the following structures:

#### ***Information***

Information is defined in the Oxford English Dictionary as “What is conveyed or represented by a particular arrangement or sequence of things” (Dictionary, 2014). The *things* arranged in sequence can include such things as neurons and brain structures (mental information); patterns of pressure and sound waves (audible speech); patterns of color or shape (written language); and other environmental cues.

#### ***Representations***

Information can typically take many forms. However, only some of those forms can be directly manipulated by the cognitive system. In order for information in the environment, such as a pattern of vibrations displacing the air in a wave pattern (sound), or a pattern of photons in the visible spectrum

(light), to be used in cognitive operations, it must be converted to a form that is compatible with the symbol system that is used internally by the cognitive system. The internal symbolic structures are known in cognitive science as *representations* (Thagard, 2012). Representations can be thought of, in practice, as *descriptions* of the things represented (Marr, 1982, p. 20).

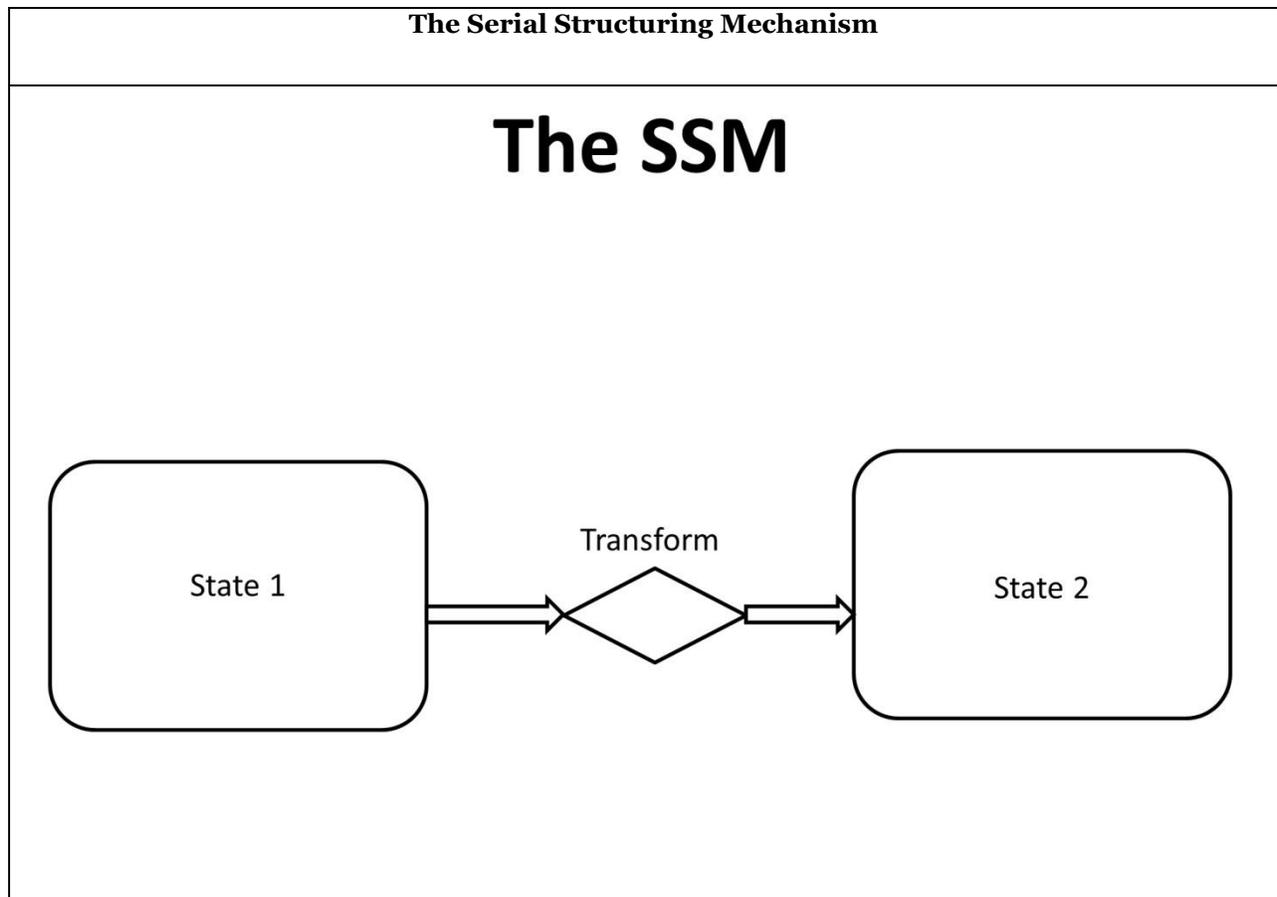
Actions — or *powers* — are capacities for action which are part of structures which constitute mechanisms. The primary power exhibited by each mechanism described below is the power of ***transformation***: the ability to change the form of the ordering of things that conveys information. This can include transforming sensory inputs into internal mental representations, transforming the form of mental representations, and transforming mental representations into signals that actuate the motor system (Card, Moran, & Newell, 1983), leading to individual action, as well as communication processes that prompt action at the distributed cognitive level. A detailed description of the transformations that are triggered, as well as the transformations that are typical to each mechanism, is included in the detailed descriptions below.

### **7.3.1 Mechanism Schemes**

Hedström and Ylikoski (2010) note that mechanisms are hierarchical, in that mechanisms at one level often presuppose the existence of mechanisms at a lower level that explain elements of its operation. This implies that descriptions of mechanisms can be modified adaptations of more general mechanism schemes.

The following two mechanism schemes have been identified in this project. They will be described here, then referred to when describing the mechanisms which are types of them.

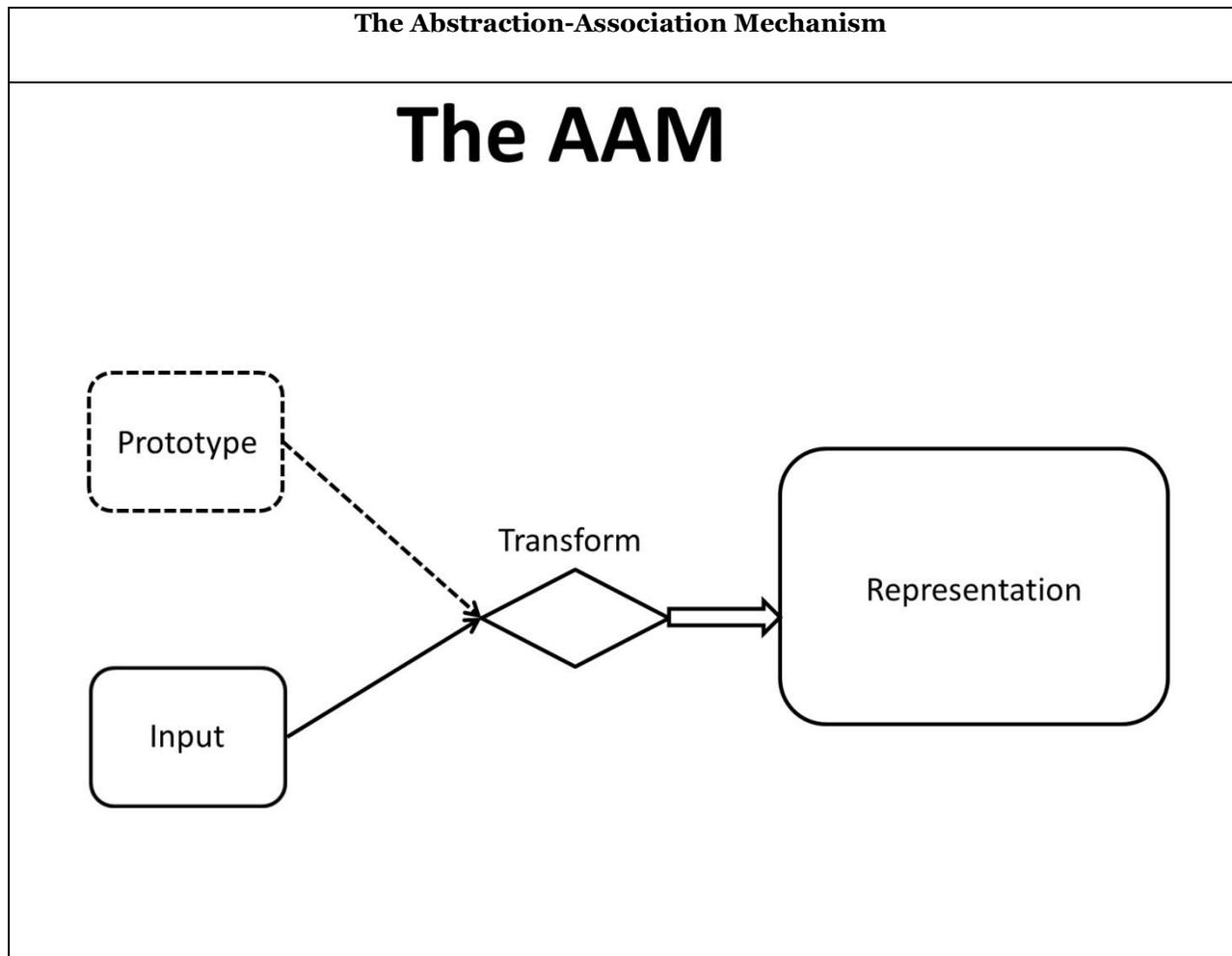
#### **7.3.1.1 The Serial Structuring Mechanism**



**Figure 9: The Serial Structuring Mechanism**

This mechanism scheme takes a representation as input. It performs some transformation on the information contained in that representation, then outputs an updated form of the input representation.

### **7.3.1.2 The Abstraction-Association Mechanism**



**Figure 10: The Abstraction-Association Mechanism**

This mechanism scheme takes two inputs: an incomplete representation of an external object or condition, that is, one which has some properties or features missing; and some type of a prototypical representation of that object or condition. The mechanism scheme combines the incomplete representation and the prototype to create a full representation of the object or condition, that is, one which has all applicable properties and features.

## 7.4 The Representation Construction Mechanism (RCM)

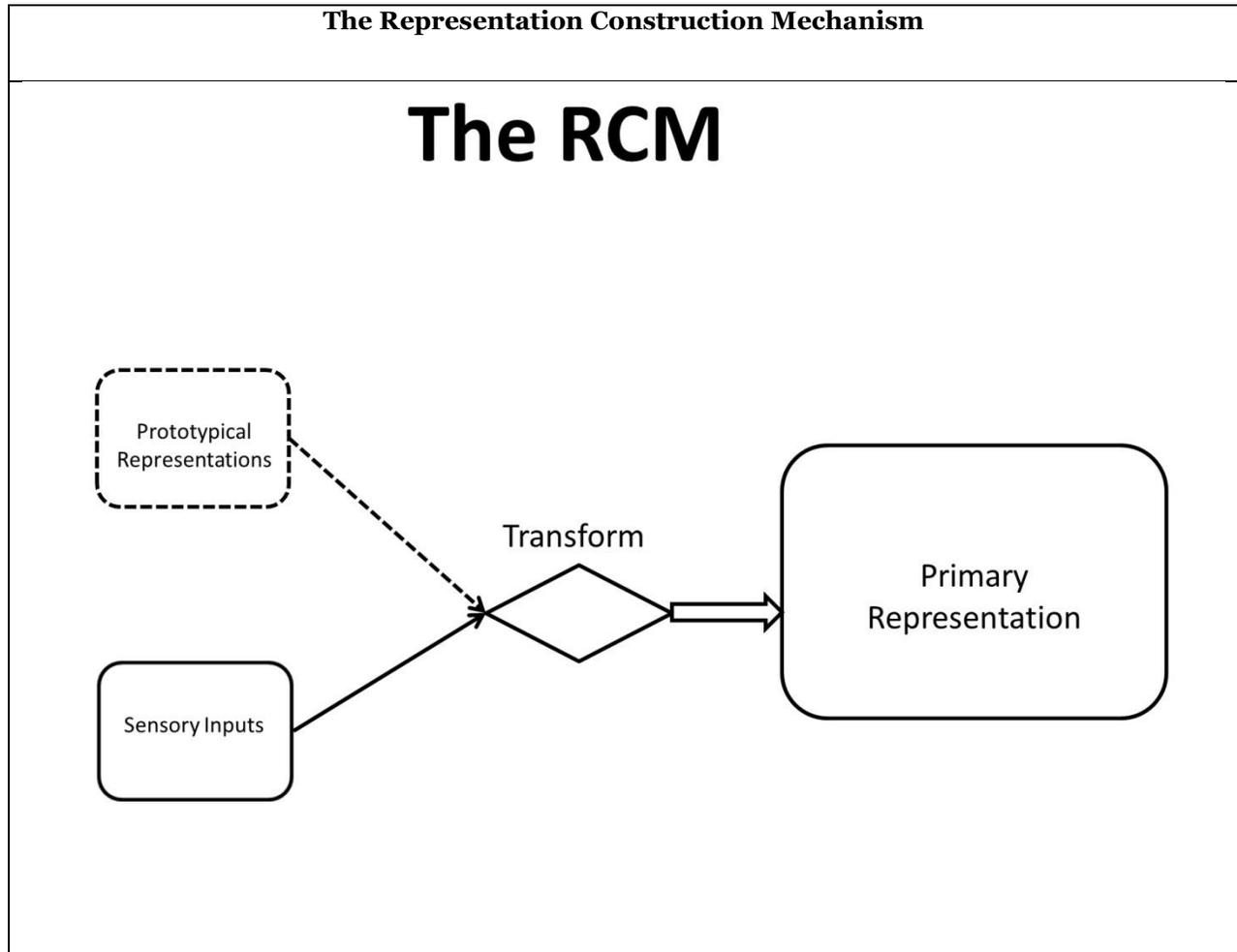


Figure 11: The Representation Construction Mechanism

The Representation Construction Mechanism (RCM) constructs the Primary Representation (PR) of the world that is held by the cognitive system at any time. It is a type of the Abstraction-Association Mechanism. It is described below.

### 7.4.1 Description

The Representation Construction Mechanism (RCM) is a type of the Abstraction Association Mechanism. Its function is to create the model of the state of the external world that is maintained by the cognitive system. The RCM takes as input incomplete information about the state of the world from the sensory and perceptual system. It also takes as input prototypical cues about the state of the world. These prototypical cues may include previously encoded learned knowledge about likely states of the world; primed

schematic representations, and predispositions based on expectations. The RCM constructs a representation of the world by combining direct and explicit sensory information about the state of the world with prototypical information to create an *associatively coherent* (Kahneman, 2011) mental model of the state of the external world: a Primary Representation (PR). It must be noted that the associative coherence of the PR does not imply its veridicality.

The following hypothetical scenario can illustrate the operation of the RCM in action.

*A hiker in the United States is walking on a trail. She is enjoying the scenery, when she hears a hissing noise, accompanied by a rattling sound. The hiker looks down and sees a snake on the trail in front of her. She recognizes it as a rattlesnake, the species which is responsible for more snake bite deaths than any other in the US. Frightened, she jumps backward, then turns and runs down the trail in the other direction.*

This brief scenario illustrates the operation of the RCM. Information about the presence of the snake is available to the hiker in a number of forms, but none of these forms are internally usable by the hiker's cognitive system. All of the information is in the form of arranged patterns of things that form *signals* that are part of the external environment which is not part of the hiker's reasoning system, and must be converted to mental representations which can be manipulated by that system. The signals in the pattern of pressure waves moving through the air must be captured by the hiker's auditory system and converted to mental representations of the phenomenon that she can understand as sound, so that she can *hear* it. The arrangement of patterns of photons that outline the object on the trail must be captured and converted to a visual image by the hiker's optical system, so that she can *see* it. None of these conversion processes are as direct or uncomplicated as they seem perceptually. The organizing of patterns of photons by the visual system into perceptual representations of objects in the visual field is a complex process that depends on both direct stimuli to the optical system and processing within the visual system in the brain. The precise steps involved in this processing is a matter of ongoing debate in the field of visual perception (Treisman & Gelade, 1980; Wolfe, Cave, & Franzel, 1989). In like manner, the seemingly-simple process of "hearing" has been shown to actually involve a complex integration of stimuli from not only the auditory, but also the visual and tactile systems (Gick & Derrick, 2009).

However, hearing and seeing the snake will not be useful in terms of motivating the hiker to take the appropriate action (avoid the snake), unless the hiker *knows* what a snake is. This phenomenon of "knowing" – what it is to know, and the nature of knowledge – has been the subject of extensive philosophical enquiry, but in this context "knowing" can be taken to mean having a mental model which corresponds in some way to a property of the outside world, or an object in the world; and contains information about the property or object. The hiker, upon seeing the snake, exhibits knowledge which goes beyond the direct sensory inputs that the signals about the snake that she has seen and heard. She knows the name of the type of snake. She knows that the snake is poisonous and dangerous. She flees

from the snake. This suggests that the sight of the snake gave her access to knowledge about the type, characteristics and behavior of the snake. How did this happen?

For the information about the presence of the snake to prompt the hiker to take the appropriate action, she would need to have a prototypical mental model that has a shape, and makes a sound, that corresponds to the object that she perceptually detects on the trail. Let us label that mental model as \$snake\$, and the object on the ground (snake). When she perceptually discerns the properties of the object on the trail, a matching-to-prototype process (Calderwood et al., 1987, p. 2) that is fast, automatic, and non-conscious (i.e., is part of System 1) occurs: a *reference linkage* (Leslie, 1987, p. 415) between the object (snake) and the mental model \$snake\$ is created. A symbolic object within the cognitive system is created that is an *instance* of the prototype \$snake\$ that *represents* the object on the ground: we can label this representation \$snake. There are some properties of \$snake that will be immediately accessible via the signals received from the environment, such as location, color, size, etc. However, there are a number of properties of \$snake of which the hiker becomes aware that do not map directly to signals in the environment. She knows type (rattlesnake), history (responsible for many deaths), appropriate response (flee), all of which are not contained in the direct stimuli.

These things are “known” by the hiker because of the properties of the matching process which occurs. The prototype \$snake\$ contains information about possible instances of the object (snake) which includes a number of pieces of information about objects of the type \$snake\$ that can be expressed in the form of *rules* (Anderson, 1993). These rules can be expressed in the form of IF..., THEN..., statements. One such rule may be expressible as:

IF \$snake has rattle on tail

THEN \$snake\_type=rattlesnake

Such rules may include further information in the form of conditional rules, which define attributes of objects dependent on values of other attributes of those objects, for example:

IF \$snake\_type=grass snake

THEN \$snake\_poisonous=FALSE

ELSE

IF \$snake\_type=rattlesnake

THEN \$snake\_poisonous=TRUE

It should be emphasized that this is not to suggest that “knowledge” in the mind is necessarily arranged according to a system of IF THEN rules. However there is a long-held consensus in cognitive science that some aspects of human knowledge can be represented with such structures (Anderson, 1993). In the case of the hiker, this prototypical knowledge — \$snake\$ — is combined with sensory inputs to construct a representation of the object (snake) within her cognitive system: \$snake\$. Attributes of \$snake\$ that are not available through direct perception are provided from the prototype, using a process of attribution that follows a logical (though often non-conscious) process that may lead to misattributions under some circumstances (see (Henrich, Heine, & Norenzayan, 2010; Scholl & Tremoulet, 2000; Treisman & Gelade, 1980)).

It is through these perceptual and attributional processes that we recognize things, understand what they are, and decide how they should be responded to. In doing so, we create representations of things in the environment. The sum total of all the things that we perceive, and hold representations of, in the environment at any given time, comprises our *Primary Representation* of the world. The Representation Construction Mechanism creates that representation, and continually updates it as perceptual inputs from signals processed through the sensory systems convey information about changes in the state of the world.

In collective contexts, the operations of the RCM correspond to information-gathering activities that may be geared toward developing a shared understanding of the true state of the external world. It may, for example, correspond to formal information-sharing processes, knowledge management or research at the organizational level. In an organizational setting, RCM operations correspond to market research, customer data analysis, and other data-gathering activities that the organization will carry out to inform strategic decision-making.

#### **7.4.2 Case Evidence**

The RCM process showed itself to be operating in each case by how participants framed the circumstances which led them to develop creative ways of appropriating the systems they were using. In the context of creative action, RCM processes can be seen as an analogue of “problem finding”, which has long been recognized as a critical element in decision analysis (Gallupe, DeSanctis, & Dickson, 1988; Pounds, 1965). For example, in the Alpha case, when faced with the fact that the software publisher was discontinuing support for the package that was critical to their workflow, many of the users of Desktop would probably have seen a need to adjust their internal processes (e.g., following the publisher’s instructions to move to Windows) in order to respond. JS, because of his experience in developing technical solutions for unstructured problems (i.e., because of the nature of his available prototypes), saw this as a technical problem they could solve by finding, or building, an alternative to Desktop. This was so, even though he and his staff did not, at first, know what form the solution would take.

In another example, in the Gamma case, the makers of Tracker – the satellite tracking device – had very different perceptions of the nature of the device they had built than MP, the manager at Gamma. MP described the problems that this difference caused:

*One was I wasn't in America and they weren't really looking at the rest of the world yet, and the other is, I wasn't thinking about tracking people, I was thinking about communicating, and I had a face to face meeting with them in October because by coincidence, I was in America anyway, and that helped to get them to understand better my thinking.*

The company had built a device for well-heeled adventurers in a particular market who would pay for the extra security of being able to send SOS messages from remote areas. They did not see the device as a tool for disaster relief. It took several discussions to change their perception of the device to one that was compatible with MP's, which would motivate them to cooperate with the project:

*But I would say that it probably wasn't until Christmas 2011, that their corporate body language said, here we have a communications device rather than a tracking device.'*

The RCM of participants in each creative appropriation incident led them to frame the problems they faced in a certain way – to develop a particular Primary Representation of the context in which they were. This shaped the subsequent decisions they made, which in turn, shaped the sequence of event that led to the outcome.

Collective level RCM processes correspond to structured information-search activities such as market research, and the use of business analytics. The structured search for an alternative to Desktop that took place in Alpha is an example of a collective RCM process. In Gamma, MP speaks of “their corporate body language” to describe the transformation of perspective on the part of the makers of Tracker.

### **7.4.3 Literature**

Perception is not simply direct conversion of stimuli to representation, it involves mental transformations that are error-prone. Treisman and Gelade (1980) demonstrated this in providing evidence for their Feature Integration Theory (Treisman & Gelade, 1980, p. 98). However, although the general finding that perception is a process and does not provide an unvarnished picture of the state of the external world, there are competing versions of exactly how it works (see Wolfe et al., 1989 for a competing version of how visual perception happens). The point is that there may be many models, but they all show perception to be a cognitively complex process that involves processing and prototypes. Therefore the RCM is supported, but is proposed at a level of abstraction that does not require the choice of any specific model of how the perceptual process occurs.

Another piece of evidence for the RCM is the work of Henrich et al. (2010). They demonstrate that many of the aspects of perception that most people regard as “normal” are, in fact, only normal for WEIRD people: that is, people from *Western, Educated, Industrialized, Rich, Developed* countries. For example, the Muller-Lyer illusion (Judd, 1905) only works for WEIRD participants. This implies that the optical calibration mechanisms that produce the illusion are part of the Tightly Compiled Learned Information (TCLI) and not the Encoded kNowledge Base (ENB) of System 1 (Stanovich, 2011). We also are aware that people have dispositions to, for example, have affective responses to different types of stimuli that are stimulus-independent.

Finally, it ought to be noted that, although examples from the literature on visual perception have been used, there is evidence that all kinds of perceptual processes are subject to the RCM (Gick & Derrick, 2009). The formation of representations results from the integration of the outputs of diverse processes into a mental model of the world, which is done non-consciously and automatically (Evans, 2008, p. 264). The RCM, as described in this thesis, is compatible with several models of perception, but is not dependent on any single model. This is an advantage of conducting the analysis at the computational theory level (Marr, 1982).

### 7.4.4 Structure

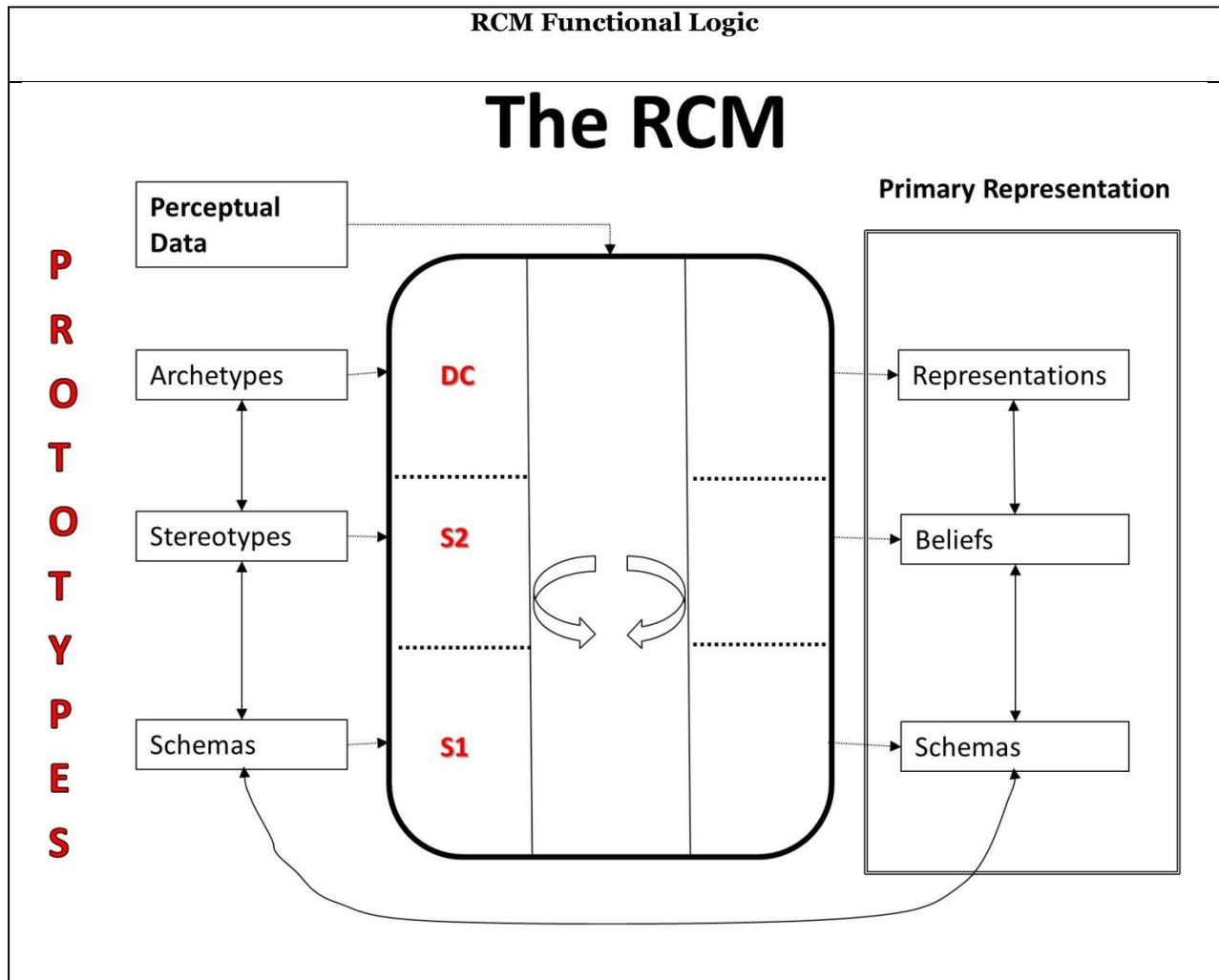


Figure 12: The RCM Logical Structure

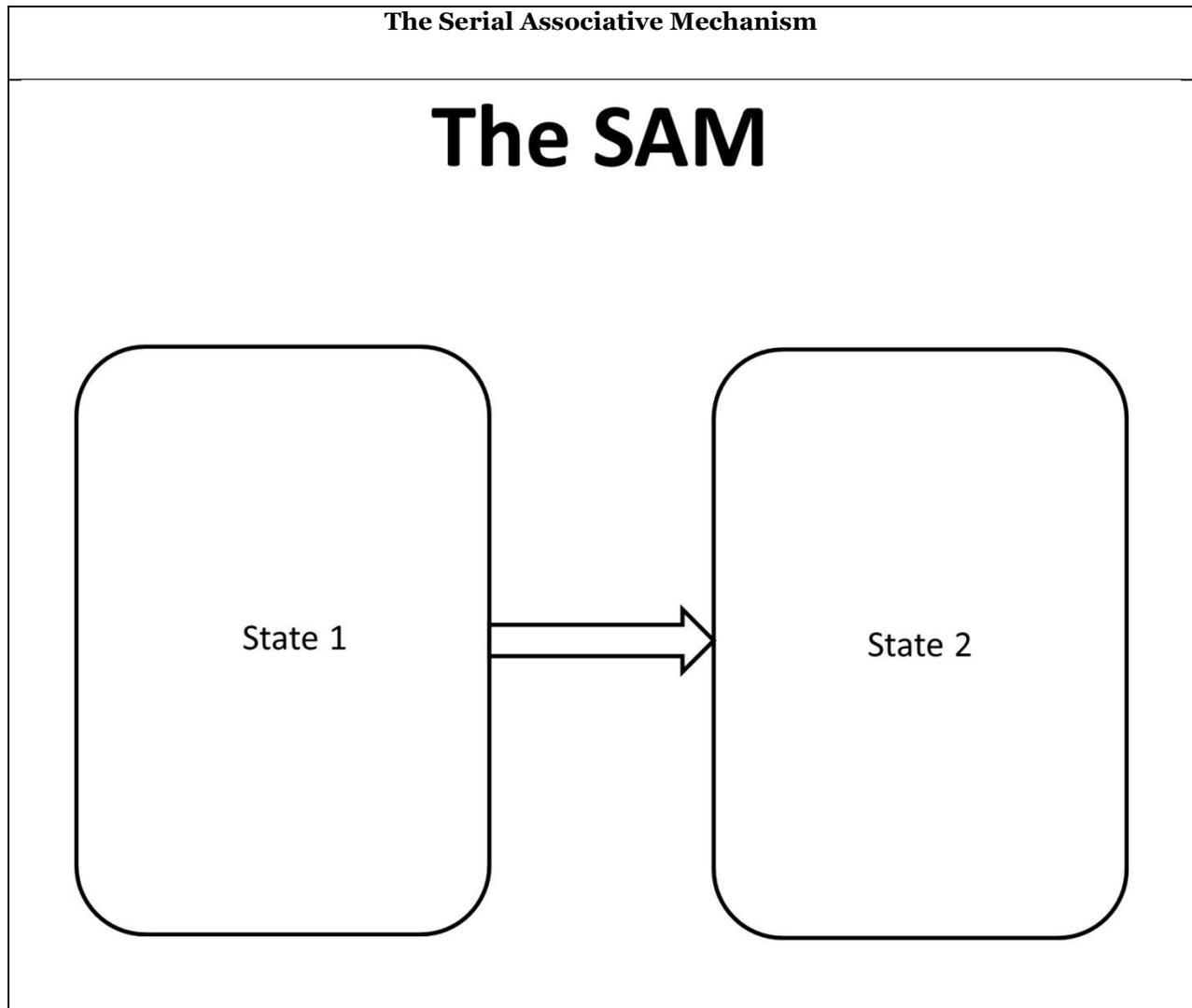
The RCM takes as input raw perceptual data from sensory inputs and other data sources (narrative accounts, etc.) It also takes as input prototypical representations of how the world is expected to be. The input prototypes differ at each level of cognition: schematic memory structures at the S1 level, stereotypical beliefs at the S2 level, and archetypal representations at the DC level. These are combined with the perceptual data to form the constructed representation of reality that forms the Primary Representation (PR). The PR contains representations of objects and phenomena in the world; beliefs about those objects and phenomena, and subconscious mental schemas that contain non-conscious representations which help to guide the construction and interpretation of the PR, and which may, in fact, differ from the conscious belief system.

Because the input prototypes are partial inputs to constructing the PR, they will *tend to* influence the structure of the PR in such a way that they are reinforced (i.e., individuals will tend to perceive reality in ways which conform to their existing prototypes). The prototypes at each level also tend to reinforce the prototypes at other levels (i.e., subconscious schemas will also tend to influence the formation of conscious beliefs and representations, and will tend to influence the shared representations of the world that are created at the distributed level).

#### **7.4.5 Conditions**

- Enabling Conditions
  - Incomplete perceptual information about the state of the world
  - Existence of prototypical representation
- Stimulus Conditions (triggers)
  - Perceptual processes
- Releasing Conditions (remove impediments)
- n/a

## 7.5 The Serial Associative Mechanism (SAM)



**Figure 13: The Serial Associative Mechanism**

The Serial Associative Mechanism executes routine, well-rehearsed, or cognitively non-demanding actions. Logically, it represents a direct change in the state of the primary representation from state 1 to state 2 without intervening transformations or combinations. It is the 'default' low-power operating mode of the cognitive system. It is described below.

### 7.5.1 Description

This mechanism is the simplest in logical form and is not a ‘type’ of any other mechanism. It takes as input the current Primary Representation (PR) of the world. If that representation contains any stimulus conditions, it associatively selects the most readily accessible response, triggers it, and updates the PR. It is equivalent to routine or familiar action, which is completed without significant cognitive engagement or effort. At the individual level, while this mode of cognition can involve tightly compiled learned information (TCLI) from System 1, this mechanism does involve System 2. However it represents a ‘low-power’ mode of operation that is not as computationally demanding as other forms of System 2 processing. Specifically, it is differentiated from other forms of System 2 processing by the fact that it involves solely *non-conditional* processing.

The SAM represents an analogue of what Stanovich (2011) identified as *Serial Associative Cognition with a Focal Bias*. As discussed in the section on cognitive science in Chapter 2, the human cognitive system is designed with an overall tendency toward effort minimization. This common way of expressing this is in the cognitive science literature is that people are *cognitive misers* (Evans, 2012b; Evans & Stanovich, 2013; Toplak, West, & Stanovich, 2011). This tendency toward minimizing the computational expense of any stimulus response is the reason why the cognitive system tends to default to the System 1 response to any stimulus. However, a System 1 response will not be available for every stimulus. Some stimuli may be novel, moderately complex, or require conscious attention, even if routine, etc. Such stimuli require a System 2 response, but may not require full cognitive engagement. This is where the SAM response comes into play. Stanovich (2011) states that people enact the tendency toward being cognitive misers by following two rules:

1. Default to Type 1 processing whenever possible
2. When Type 1 processing is not available, default to Serial Associative Processing with a Focal Bias

Serial associative cognition involves moving from stimulus to response without evaluating alternate possible responses. That is, it represents linear sequential response without conditional processing. Consider two models of the cognitive approach to the same task: brushing one’s teeth:

**Model 1:** *I need to brush my teeth. I locate my toothbrush on the shelf below the mirror. I pick up the brush, pick up the tube of toothpaste beside the brush and squeeze toothpaste from the tube onto the brush. I wet the brush under the tap, and then use it to brush my teeth.*

**Model 2:** *I need to brush my teeth. Wait a minute, if I brush my teeth, it will take me 2 minutes longer to get ready. Do I have time? Oh well, I’ll go ahead and brush my teeth. I locate my toothbrush on the shelf below the mirror. I pick the brush, pick up the tube of*

*toothpaste beside the brush and; wait a minute. The cap isn't on the toothpaste. If the toothpaste is uncapped it might be dry. I don't want to use dried-out toothpaste. I wonder if...*

The difference between Model 1 and Model 2 can be summarized by a single word which is present in Model 2, but absent in Model 1: the word **if**. The word “IF” represents the philosophical foundation of the concept of hypothetical thought, conditional logic, and a number of important psychological and philosophical topics concerning reasoning and behavior (Evans & Over, 2004). The flow of the cognitive process in Model 1 is *continuous*, while in Model 2, the flow of cognition is repeatedly *interrupted*, and alternate possible future states of the world are evaluated in order to determine the optimal behavior to be performed. While I will shortly revisit the significance of IF, I will for now define the SAM as cognitive processing – which includes behavior – which does not entail the concept of IF.

A useful metaphor for SAM processing may be found in the concepts of *hub* and *wheel*. The hub – around which SAM processing revolves – is found in the routines, standard procedures, over-learned (automatic) responses, and other forms of processing which are not cognitively demanding and conform to recognizable patterns (walking, driving, tooth-brushing, etc.). The wheel is found in the particular performance of these recognizable SAM procedures: e.g., driving to work this morning. This is closely related to (Feldman & Pentland, 2003)'s concept of routines involving an ostensive and performative dimension.

This mode of processing is both common and highly versatile. There are many complex tasks which are commonly done in a routine or habitual manner, and SAM processing can be surprisingly versatile, at both the individual (Kahneman, 2011) and collective (Feldman & Pentland, 2003) levels. Habitual cognitive processing, also seen as a kind of goal-directed automatic processing (Polites & Karahanna, 2013), has been a topic of interest in IS research on continuing use of systems, and has spurred calls for further research (Guinea & Markus, 2009). However the SAM goes beyond habit. Novel behaviors which are carried out in a non-conditional manner without hypothetical thinking are also part of the SAM. The fact that there is only one model of the world used in SAM cognition, rather than conditional evaluation of multiple worlds, is the reason why Stanovich (2011) refers to this mode of cognition as Serial Associative Cognition with a Focal Bias.

In an organizational setting, SAM operations correspond with following organizational routines and standard procedures.

### **7.5.2 Case Evidence**

The Serial Associative Mechanism is active when routines are followed, when well-learned actions are carried out or regular procedures are followed. This is the default method of stimulus response and tends

to remain stable unless the performative aspect of a routine becomes so atypical that the SAM response cannot be maintained. For example, in organization Beta, after the production department designed their procedure for communicating with the factory in China using Process and email — in response to a crisis — almost twenty years ago, the procedure continued to evolve for a few years in response to weaknesses that emerged in different elements of the process. However, when the “bugs” were worked out of the system, it became stable and has not changed significantly since. As was said by KT, who developed the system with her staff:

*“I mean, it hasn’t changed a lot, we’ve kept the same format.”*

After the change of the system from the faxing of paper documents to the sharing of the Product file, as soon as the new system met their requirements it became routine and was not changed. This despite the fact that KT’s job requirements have changed over the years, and there has been considerable turnover of staff. None of these individuals have changed the method of appropriating Product significantly.

The fact that the SAM mode of processing requires little cognitive involvement and effort makes it efficient, and therefore useful under conditions when there is significant competition for attention and cognitive capacity. For example, in the Gamma organization, MP said the following when discussing a significant problem in disaster zones — getting untrained individuals to use proper radio procedure:

*“But once again, that also means that we don’t have to introduce people to a new way of thinking when they’re stressed, or as [KF] began explaining it, when you are deeply stressed all you have are headaches, your ability to think narrows and narrows and narrows which means there are only two approaches, one is to train to the point where unusual things like talking on a radio are a habit or give people tools that **use their habits.**”* [Emphasis mine]

MP was discussing the fact that using familiar tools reduces cognitive load and increases the efficiency of untrained responders’ thinking and performance. This was seen as one of the key advantages of using mobile phones in the Gamma system, and reflects what would be expected from the SAM.

At the collective level, SAM procedures are analogous to routines. For example, in the Alpha case, when faced with the removal of support for Desktop, they began their search for a solution with a structured search for a suitable alternative, in much the same way that they approach structured searches for solutions in their consulting work. In Gamma, when MP was discussing his desire to use Tracker as part of the Mobile Data platform, he was, in effect, trying to break a routine on the part of Tracker’s manufacturer. The company, which is well established and has a history of putting out products, was going through the routine of marketing a product with a defined use case. It took some effort for MP to convince them to disrupt that routine.

### **7.5.3 Literature**

Many thinking and reasoning tasks can be accomplished in one of two modes: by System 2, or by System 2 supported by System 1. In the latter mode, a pattern of systematic errors in reasoning can be measured that result from patterns in the operation of System 1 (Kahneman, 2011; Kahneman & Tversky, 1979; Tversky & Kahneman, 1974, 1983a). There is substantial evidence that most individuals spend most of their time in this mode of reasoning. This mode corresponds to the SAM.

It should be reiterated that this reasoning mode does not correspond to non-consciousness. Many routine tasks: brushing one's teeth, driving a car on an open road, etc., do not require significant mental effort, but do require conscious awareness. It is also possible to direct more attention to these tasks voluntarily, or to stop doing them. This means that they are not part of the System 1 response system, which is automatic. However, the two systems work in tandem, and System 1 is always "helping" System 2. That means that the 'suggestions' that are made by system 1 are more likely to be applied in SAM mode by System 2. The view that there are conscious processing modes that are conscious and volitional, but require low cognitive absorption and are highly reliant on System 1 processing are also reflected in dual-process theories (S. Chen & Chaiken, 1999) from social cognition (Evans, 2008, pp. 267-268).

At the individual level, the SAM mode of cognition seems to display reduced efficiency when called on to perform task switching (Monsell, 2003), or perform multiple tasks simultaneously (Rosen, 2008). More evidence that it is a low-power mode of system 2, rather than a type of system 1.

In the same way that following S1-driven routines in can lead to heuristic-led errors in individual cognition (see (Tversky & Kahneman, 1974)), heuristic processing can lead to errors in collective-level cognitive processes – e.g., the reviewing of academic publications, as in famous hoax publications by Epstein (1990), Skokal (1996), and, more recently, Duiric, Delilbasic, and Radisic (2013)

## 7.5.4 Structure

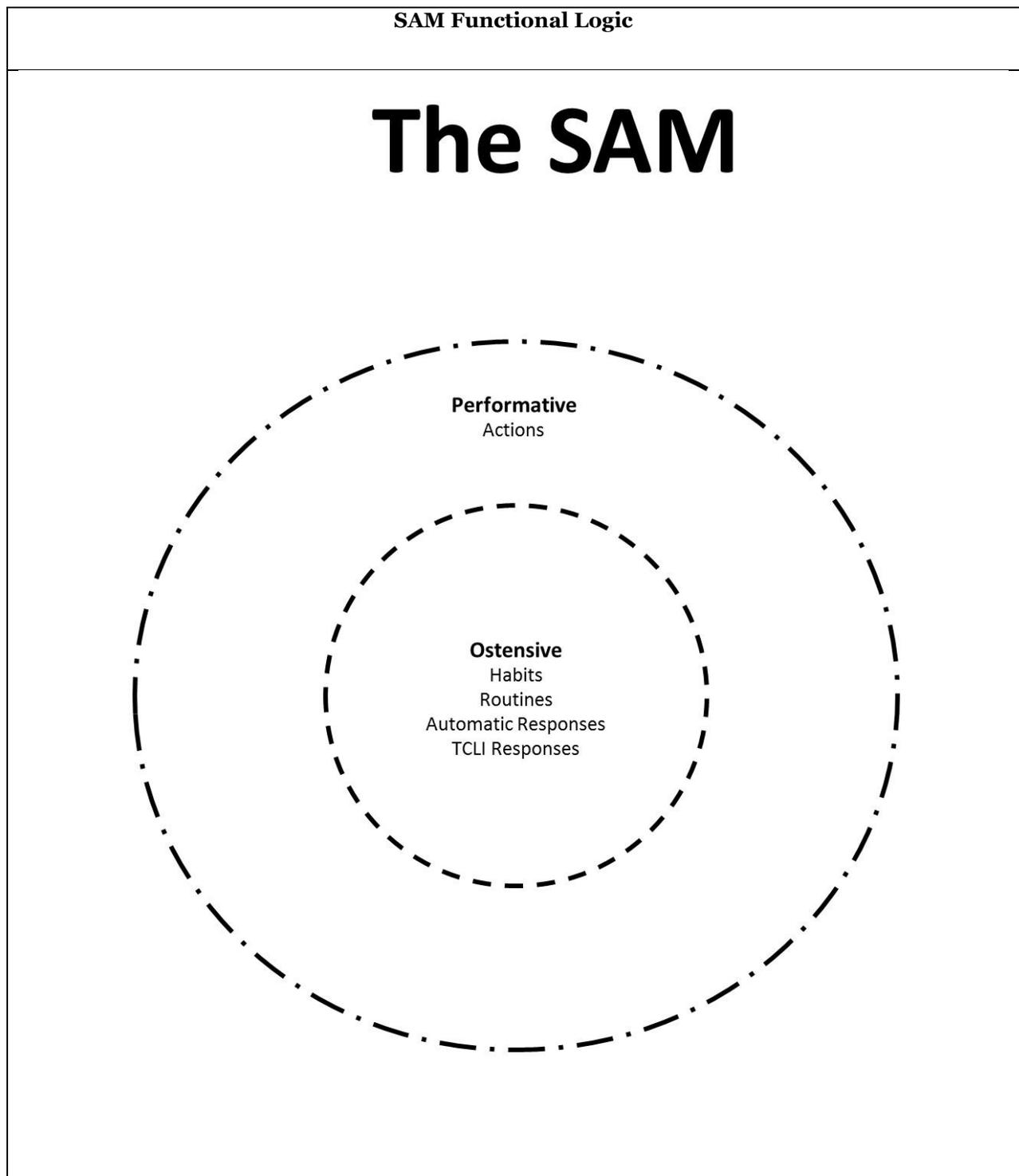


Figure 14: The SAM Logical Structure

The SAM has the simplest logical structure of any of the mechanisms. It takes as input the current state of the Primary Representation (PR). At its core are habits, routines, built-in automatic stimulus responses and overlearned responses (TCLI). These semi-automatic responses act on the PR, triggering default behaviors, and updating the state of the PR in a continuous, ongoing process. SAM operation is partially conscious, but is driven by the most-available low-cost responses that rely heavily on the non-conscious System 1. SAM operation *tends to* continue unless and until it is interrupted.

### **7.5.5 Conditions**

- Enabling Conditions
  - Well-learned, non-novel task
  - Lack of stimuli calling for increased attention
- Stimulus Conditions (triggers)
  - Any (default response mode)
- Releasing Conditions (remove impediments)
  - Normative contextual conditions

## 7.6 The Decoupling Mechanism (DM)

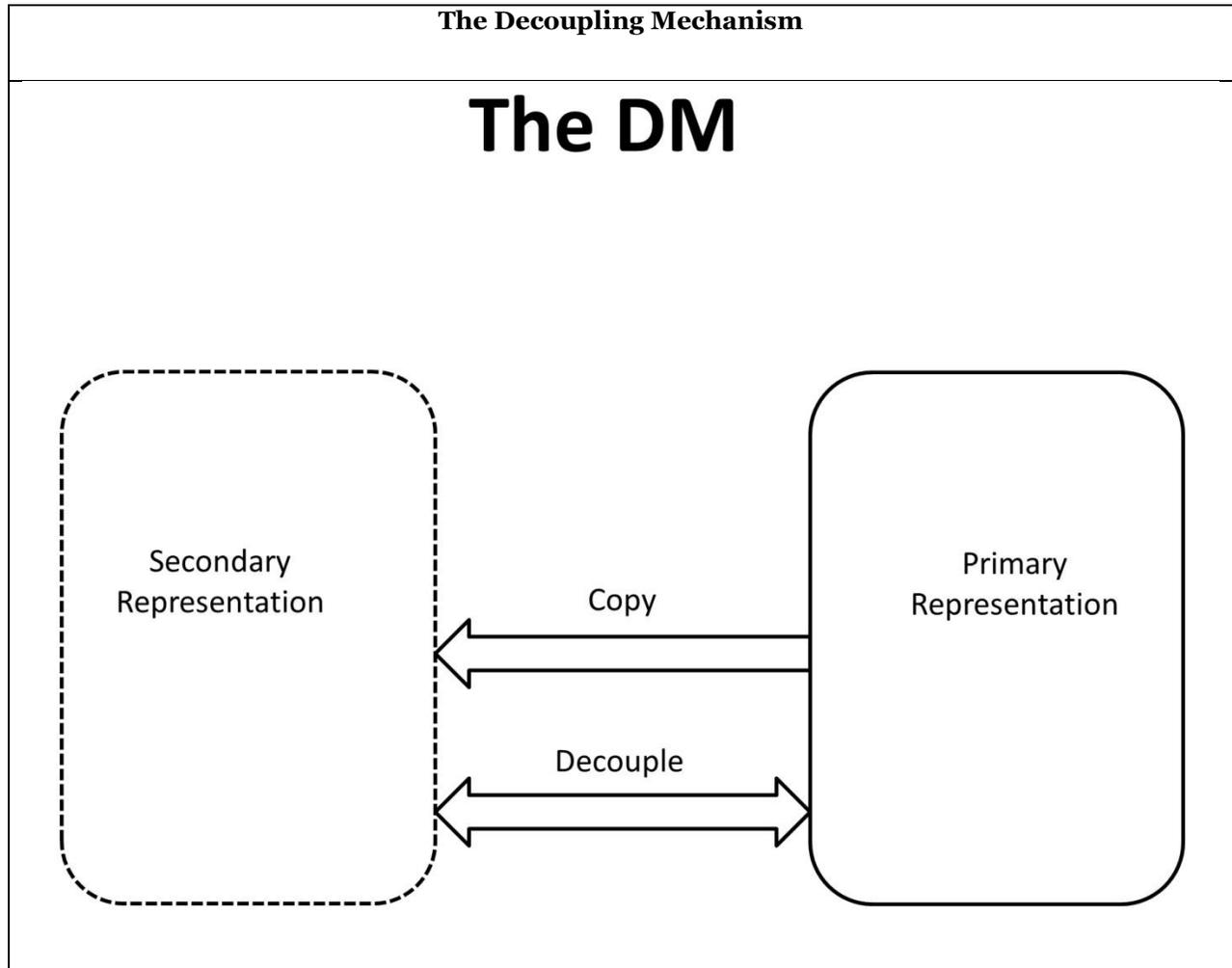


Figure 15: The Decoupling Mechanism

The Decoupling Mechanism (DM) executes two logical operations: *Copy* creates a secondary copy of the state of the Primary Representation, designated the Secondary Representation; *Decouple* maintains a separation between the Primary Representation and the Secondary Representation. It is described below.

### 7.6.1 Description

The Decoupling Mechanism (DM) is the ‘trigger’ for creative activity. It is triggered when a stimulus condition occurs that requires conditional reasoning – that is, the consideration of several ‘alternate worlds’ in which the consequences of following each of several possible paths of action is simulated in order to compare outcomes and choose an optimal stimulus response.

To illustrate the operation of the DM, I will propose the following hypothetical scenario.

*I am considering buying a green jacket. I go to the store, but none of their green jackets fit me. They have jackets in my size, but they are all red. The store offers to order a jacket in green in my size, if I wish. I borrow one of their red jackets and wear it in front of the mirror while pretending it is green, in order to see how the green jacket will look on me. I then decide whether or not to have them order the jacket.*

The preceding scenario seems unremarkable and ordinary. Most persons of normal cognitive ability would have little difficulty performing the actions described in the scenario. However, it acquires a deeper significance when considered in light of the working of the Representation Construction Mechanism to construct a Primary Representation. In that representation, there must exist an object \$jacket\$, or else I would not know what a “jacket” is, in order to consider buying one. I encounter an object in the world, a (jacket). A symbol is created in my cognitive system – \$jacket – that is linked to the object (jacket) in the external world. The symbol \$jacket is assigned attributes that correspond to the attributes of the object (jacket), including the attribute color=red. This symbol is my primary representation of the object (jacket) in the world.

However, in front of the mirror, I then assign the attribute color=green to the symbol \$jacket. The dangers of this assignment should be clear on reflection. The object (jacket) has not changed, and the signals that it sends to my sensory system remain the same. The wavelength of electromagnetic radiation that my eyes detect when I see the jacket remain the same as those that I have a model in my primary representation for, such that “this\_wavelength=red”, but now I have changed that representation so that “red=green”. If I am not careful to reverse this assignment, it is possible that I might corrupt the model of color in my primary representation, so that “red=green”. The consequences of this could be catastrophic. Consider the possible outcome if I were to drive toward an intersection in my car at high speed, while believing “red=green”. Leslie (1987) calls this possible phenomenon “representational abuse”: the corruption of the model of the world maintained by the primary representation so it becomes impossible to know the actual state of the world. However, except in cases of severe pathology, this almost never happens. Why is that?

It might be thought that because I have long experience with color, the temporary assignment of “red=green” will decay with the current contents of short-term memory, while the more stable pattern of “red=red” will remain in my long-term memory. However, the capacity to randomly reassign the attributes of symbolic entities in the cognitive system, or even create symbols for entities which do not exist in the real world – the capacity to *pretend* – emerges at roughly the same time that the capacity for representation emerges: at the beginning of childhood (Leslie, 1987). Psychologists have explored this question in depth, and have concluded that this requires the existence and coordination of at least two representational structures (McCune-Nicolich, 1981). Leslie (1987) proposed a model of these

representational structures, and how they are related, that has been highly influential, and has provided a foundation for a great deal of research on the structure of the reasoning system (Stanovich, 2011).

Leslie (1987) proposed that what defines objects in the primary representation is that each of those objects has a direct semantic relationship to an object in the world (Leslie, 1987, p. 414). This is why the primary representation can safely direct behavior: if there is a symbol – \$snake – that is part of the primary representation, it is linked to an object (snake) in the real world. The cognitive system can therefore enact a behavioral response to \$snake that is appropriate (e.g., run!), given the fact that it is linked to an object that has the same characteristics in the external world. To pretend that a snake were some other object – e.g., a stick – would endanger the ability of the primary representation to cue appropriate behaviors unless the pretend representation is somehow quarantined from the primary representation (Leslie, 1987, p. 415). Leslie (1987) provided a model of a cognitive mechanism for accomplishing this which he labeled the *decoupler*. The decoupler creates a copy of the primary representation which inherits objects, properties and prototypes from the primary. Leslie (1987) labeled this copy a *metarepresentation* but later researchers have labeled it a *secondary representation* (Stanovich, 2011). Objects in the secondary representation are distinguished from those in the primary representation by their *opacity* (Leslie, 1987, p. 416). In the primary representation, the symbol \$snake is *transparent*, in that one can “look through” it to see a real object with real attributes: (snake), since \$snake is linked to (snake). The symbol #snake in the secondary representation is *opaque*, in that it is not linked to any object in the real world. One may change its fundamental attributes (“#snake=stick”), and simulate behaviors based on those changed attributes (pick up stick). Meanwhile, the symbol \$snake, in the primary representation, will continue to represent external reality and guide appropriate behavior in the real world (run from (snake)).

The DM represents the basic decoupling procedure described by Leslie (1987), but operates at a higher level of abstraction. I propose that the *same basic mechanism* which explains pretense also explains the creative appropriation of IT systems by users. Using AFT terms, when a user uses a system, she develops a System Representation (SR) that has a *reference linkage* (Leslie, 1987, p. 415) to the Technical Object (TO) that constitutes that system in the external world, which we could label as \$system. This SR will include properties – functionally equivalent to attributes – that describe the purpose or intended uses of the system, the full mental set of such attributes would be part of a prototype we could call \$system\$. In order for the IT system to be appropriated creatively, the user will need to evaluate different possible ways in which the system could be repurposed: that is, evaluate different possible appropriation moves. The user will develop and evaluate different possible moves in a cognitive process that involves creating a copy of the symbolic representation of the system (creating #system, an instance of a broader prototype #system#); simulating different ways of appropriating the system (manipulating the attributes of #system), and selecting a novel way of appropriating the system. The Copy and Decouple operations – or

transforms – by the DM, provide the abstract forms of #system and #system# that enable these manipulations to be carried out. Both operations are highly computationally expensive.

In terms of dual-process theory, the decoupling mechanism involves sub-mechanisms at both the System 1 and System 2 levels. Decoupling operations involve the voluntary allocation of attention resources. However, such operations also involve the copying and maintaining of a dual set of models of the world. Not all aspects of that process are conscious. The model proposed in this thesis specifies that both System 1 and System 2 are involved in the process, but does not specify how the different levels operate, in order to maintain the level of abstraction at which the specified mechanisms operate.

At the collective level, the operations of the DM correspond to deliberate or formal activities aimed at planning, problem solving or idea generation which are non-routine. They include the kinds of activities one might see in the setting up of formal structures for evaluating strategic options, building R&D capacity, or the creation of ad-hoc committees for generating responses to specific challenges.

### **7.6.2 Case Evidence**

The Decoupling Mechanism (DM) is active when users break with the routine or normative way of using a system and begin searching for ways in which to appropriate the system which are novel and are not based on an existing model of how the system is used. This process of searching for new ways to apply the system is accomplished through a process of simulation that may be mental (thinking of new ideas about how to use the system), social (engaging in group-based brainstorming, generating and evaluating ideas as a collective), and material (developing and “trying out” new ways to use the system before fully implementing them).

All three types of simulation can be seen in the case involving organization Alpha. The initial crisis – the cancellation of support for their preferred version of the Desktop application – caused them to embark on a search for a new way to produce their report. This search was a collaborative process, and involved testing normative appropriation patterns for a number of publishing packages, but none of them suited Alpha’s needs. They then broadened their solution search by deciding to build their own solution. They also broadened the scope of their collaboration by going to the university for help with the problem. While they were doing this, DL – the computer science student – heard about their problem and had an idea about how his work with a text formatting language could be applied to it. He built a rough prototype, which Alpha then hired him to build out and implement. In each of these steps, cognitive simulations – ideas about what could work and how – were developed and tested. Most of them were developed, tested, and eventually rejected. Even DL’s prototype was a simulation based on an idea about what *might* work, rather than a fully fleshed-out solution, but DL’s idea was cognitive simulation that was enacted physically into a material object: a distributed cognitive simulation.

The same pattern — developing ideas, trying them out, then building a solution based on an idea that performs promisingly in testing — can be seen in each of the cases. At a high level of abstraction, most, if not all, creative accomplishments will be the result of a similar series of steps. As such, I propose that incidents of creative appropriation will *tend to* (Wynn & Williams, 2012, p. 791) involve the activation of the DM.

The evidence from the quasi-experiments shows evidence gives further insight into nature of the DM. Users within Phi hacked the system Process a large number of times. The lead developer of Process put it this way:

*“... I think once they’ve been put through that process a couple of times where they’ve requested a feature change and then given a timeframe that is impossible for them, they would have simply stopped asking and they will build stuff as they can.”*

This stands in contrast to the Finance department, which has people with similar skills (most of the employees at Phi have advanced technical skills) but have never, apparently, modified the system. This pattern is also seen in the “negative cases” of Theta and Kappa. In both companies there are skilled users with access to Resources, Techniques and who have (at least, in the case of Theta) high Motivation to be creative. As is noted in (K. D. Miller & Tsang, 2011, p. 152): “Contrasting cases can provide evidence from natural experiments regarding how mechanisms operate under different conditions.” After analyzing the differences between the contexts in which systems were creatively appropriated and not, it became clear that perception of risk of loss was what drove users to appropriate creatively, rather than an altruistic “stage” of implementation of the system (Jasperson et al., 2005; Saga & Zmud, 1993). There was no instance in which users spontaneously “experimented” with the system to extend its functionality in the manner suggested by stage hypotheses. The explanation for this can be seen in the activational characteristics of the DM. As MP of Gamma said concerning his ideas about repurposing systems:

*“I can’t be creative on demand, these ideas come when I’ve got a problem to solve”.*

The DM is, like the rest of the cognitive system, biased toward effort minimization (Kahneman, 2011). The cognitive system is also biased to avoid uncertainty and risk (Kahneman & Tversky, 1979). To initiate a simulation process goes against both biases. The simulation process is cognitively expensive and the outcome of a simulation process is inherently uncertain. It is therefore the *tendency* (in CR terms) of the DM to *not* fire; except in circumstances where the system perceives a risk of high losses if it is not initiated. Patterns observed in studies of reasoning support this tendency (Stanovich, 2011, pp. 49-51).

### 7.6.3 Literature

The model of the operation of the reasoning system that underlies the DM is based on (Leslie, 1987). This model and has been very influential in the literature (almost 3,000 citations on Google Scholar), and is still a foundation for theories of cognition being developed today (Cosmides & Tooby, 2000; Evans, 2012b; Evans & Over, 2013; Stanovich, 2009; Stanovich, 2011).

The patterns of behavior predicted by the DM have been extensively and consistently recorded in studies of reasoning and decision making (Kahneman, 2011; Kahneman & Tversky, 1979; Morewedge & Kahneman, 2010; Tversky & Kahneman, 1974, 1983a). Routine processing strategies result in systematic biases in decision making due to the application of heuristic processing strategies. The use of heuristic strategies is opaque to the cognitive actor because of a tendency to develop confabulated memories of the cognitive process (Evans, 2009). However, deliberate processing strategies or the presentation of problem types which are beyond the capabilities of the “routine” processing system can result in more explicit serial processing which does not depend on the heuristic strategies (Hess, 1965; Kahneman, 2011).

### 7.6.4 Structure

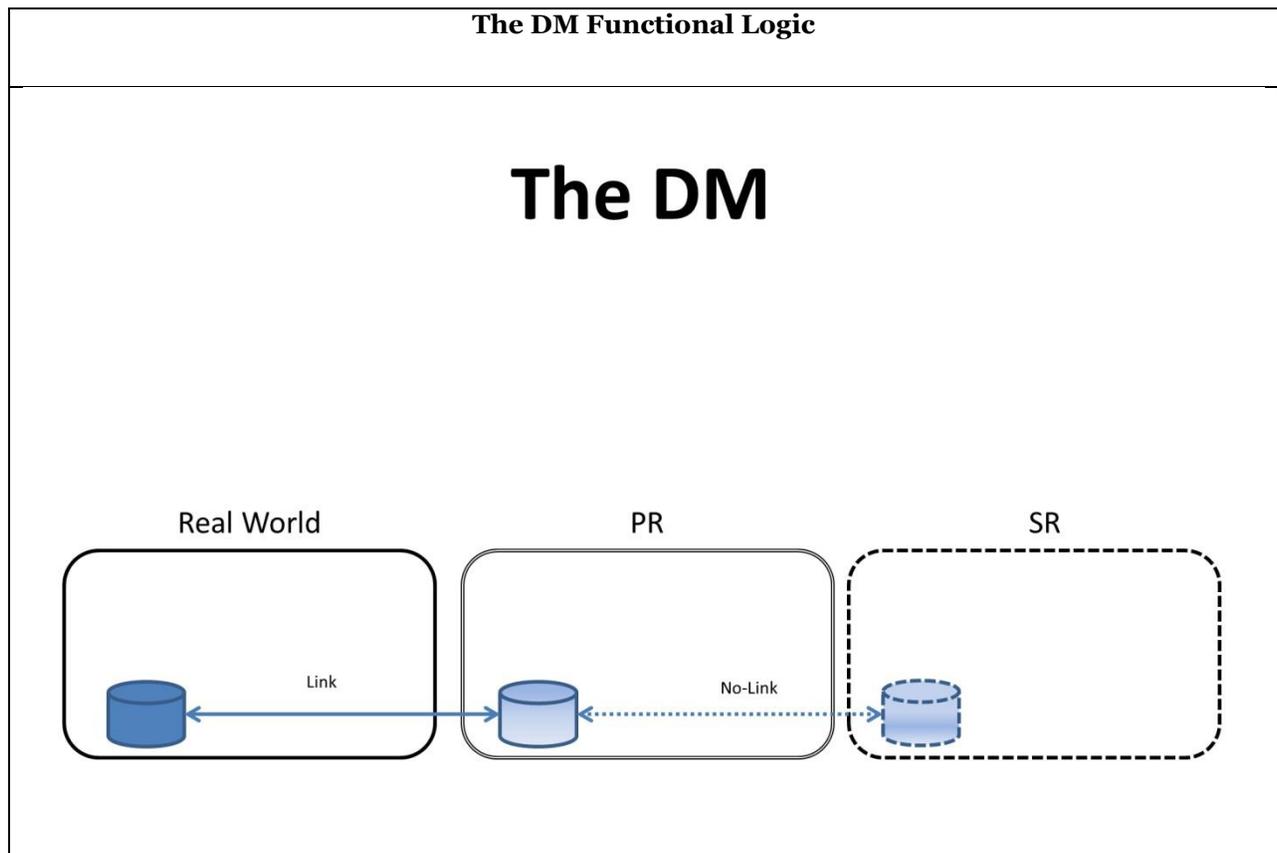


Figure 16: The DM Logical Structure

The symbol system linked to real-world objects that is created by the RCM creates a Primary Representation of the world, which guides the behavior of the cognitive system. Objects in the PR are linked to objects in the real world and thus provide a platform for interacting with the world. The DM creates a parallel symbol system (the Secondary Representation) that is *unlinked* – objects in it have no semantic connection to objects in the real world. Those objects can therefore be manipulated without real-world consequence: i.e., they can be used in simulations of actual behaviors.

### 7.6.5 Conditions

- Enabling Conditions
  - Perception of process losses from continuing current methods
- Stimulus Conditions
  - Anxiety
  - Novelty
  - Complexity
- Releasing Conditions (remove impediments)
  - Available attention resources

## 7.7 The Attribute Substitution Mechanism (ASM)

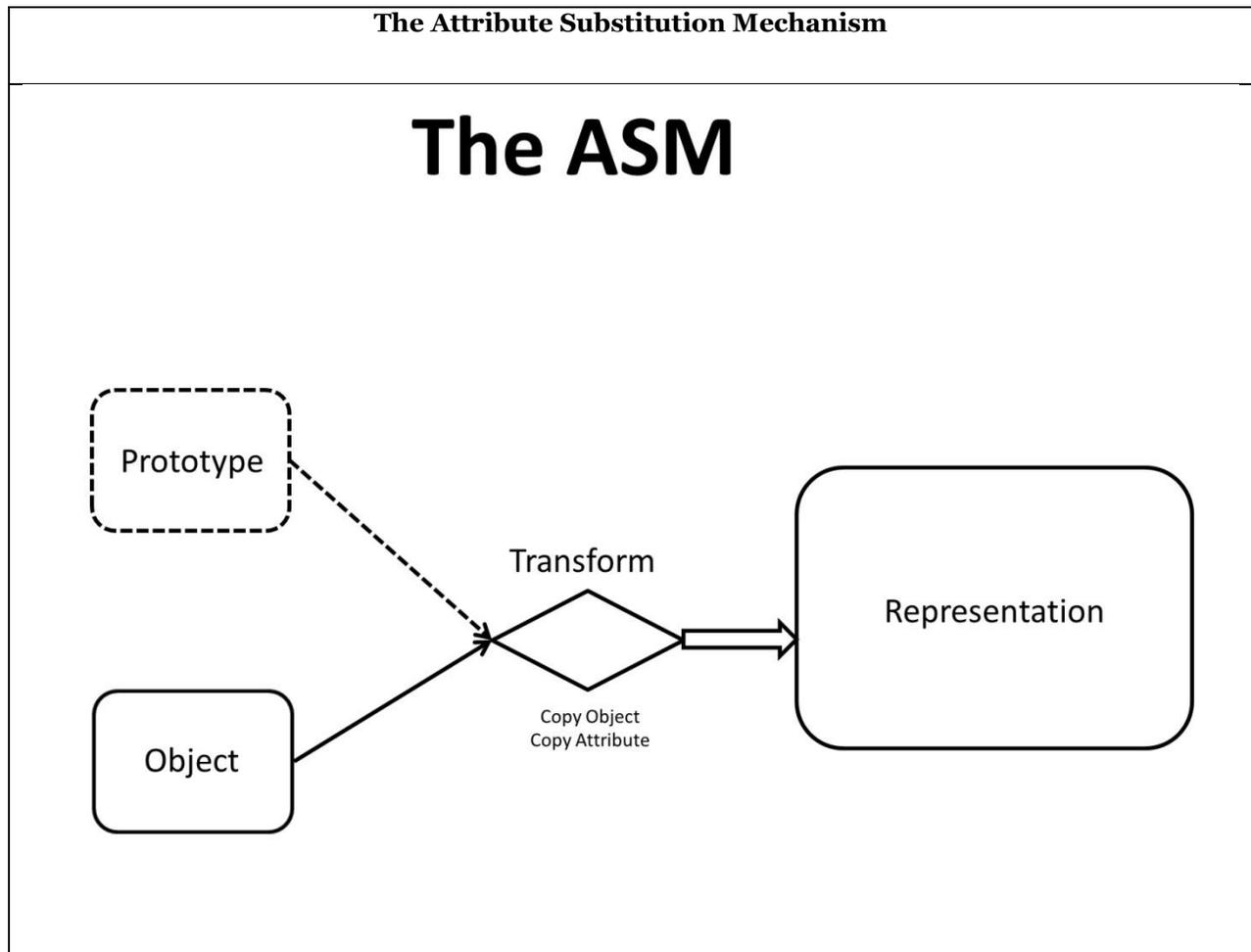


Figure 17: The Attribute Substitution Mechanism

According to Leslie (1987) there are three types of operation which are fundamental parts of the Simulation process which takes place in the Secondary Representation. They are:

- *Object Substitution*: Making one object stand in for another
- *Attribution of Pretend Properties*: Modeling properties for objects that do not correspond to reality
- *Creating Imaginary Objects*: Inventing objects that are not there

Two of these fundamental operations are performed by the Attribute Substitution Mechanism (ASM), which is a type of the Abstraction-Association Mechanism.

These are:

- Object Substitution
- Attribution of Pretend Properties; IFF (IF, and only iF) those properties are *copied* from another object that actually has them

It is described below.

### 7.7.1 Description

One aspect of the simulation process that takes place within the Secondary Representation is substitutive, it can be thought of as *analogical thinking*. There are multiple definitions of “analogy” (see Keane and Costello (2001)), but one influential definition is that of Gentner (1983): “an analogy is an assertion that a relational structure that normally applies in one domain can be applied in another domain” (Gentner, 1983, p. 156). “Domain” in this context is taken to mean systems of objects, as well as attributes of and relations between those objects, which is functionally equivalent to the contents of the cognitive system’s representations at a given time. The logical operation of substituting one object for another (“Let’s imagine that the snake is a stick”); or substituting the attributes of one object for attributes of another (“Let’s imagine this red jacket is the same color as that green one”) is performed by the Attribute Substitution Mechanism (ASM).

The ASM takes an existing exemplar: an object, action or concept. It selectively drops attributes of that exemplar to create an abstract prototype. It then copies attributes of an object, task (action) or idea (concept) from another exemplar to the first, in order to create a new exemplar. The ASM performs two of the operations involved in simulation according to the model proposed by Leslie (1987). They are Object Substitution – in which one object is made to ‘stand in’ for another, and Attribution of Pretend Properties – IFF (IF, and only iF) the pretend properties are copied from another object which actually has them. Analogical thinking – information processing as performed by the ASM – is used not only in problem-solving but also as a communication tool (Dunbar, 2001). Though analogical thinking represents a *type* of operation performed by the ASM, the mechanism itself is proposed to be more general than the strict definitions sometimes used in studies of analogical thinking. For example, the use of *metaphor* would not fit into some of the more strict definitions of analogy in cognitive science, but fits comfortably within the range of operations covered by the ASM.

In a collective setting, ASM operations are part of such exercises as the construction of models in order to analyze real-world processes; the use of metaphor for communication and metacognitive operations as part of interpersonal interactions. Studies of group decision-making have shown that analogy is a key process involved in both distributed cognitive activities and the communication processes that are part of those activities.

### **7.7.2 Case Evidence**

The ASM is a key part of the ideation process. Some theorists of cognition hold it to be the key part of not only ideation, but thinking in general (Hofstadter, 2001). As such much of the case evidence could probably be used as evidence for the operation of the ASM. However, there are some specific instances that show analogy being used in particularly clear ways.

One is in the Beta case in which the new IT manager solved a problem with communication with the firm's customers by using a Product file as, essentially, a communication tool. This was highly similar to the way in which the production department had used a Product file as a communication tool to solve a communication problem with the firm's suppliers many years before. The interesting part of this case is that none of the participants remarked on or seemed aware of the fact that the two solutions were so similar. Further, the new IT manager would have just joined the company and been introduced to the IT systems being used for critical business processes, so she would have been well aware of the way that the production department had solved their problem. This could be modeled as an operation of the ASM.

One notable attribute of the Beta case is that the working of the ASM seemed to be transparent. That is, key players in the creative incident seemed unaware of the evidence that the spec sheet case may have served as a model for the order book case. This was not the only occasion in the case evidence in which a situation that seemed to be evidence for an analogical transfer was not perceived that way by the persons involved. For example, in the Gamma case, there was the novel idea that KF had — during the training exercise in which they were testing Mobile Data — for using mobile phones in a way very similar to the way in which phones were being used in Mobile Data, but to solve a different problem. Again, both KF and MP did not appear to see the possible connection. However, there is nothing intrinsic to the ASM that requires it to be transparent. For example, in the Zeta case, RF related to me the fact that he encountered the coding-practice website online, and it gave him the idea for what eventually became the PySoc module.

ASM processes can also be seen working at the collective level. For example, again in the Gamma case, when MP was negotiating with the manufacturers of Tracker, what he was essentially doing was guiding them to use a different system metaphor to describe the nature of their product: from a tracking device to a communication device. The notion of identifying what the product was, was essentially a matter of applying a certain template to it — and MP got them to change the template.

### **7.7.3 Literature**

The operation of the ASM is analogous, in many ways, to the use of analogy in thinking.

Analogical reasoning has been proposed to be a core process in cognition, and a part of a number of processes (Hofstadter, 2001; Thagard & Shelley, 2001). It is an important topic in psychology (Holyoak & Thagard, 1997). The precise algorithms behind the implementation of analogy in the human reasoning system is the subject of ongoing debates in the literature (Gentner, 1983, 2010; Keane & Costello, 2001). The ASM is also reflected in several basic mechanisms of creative cognition in the literature such as *Conceptual Combination* and the use of *Metaphor* (Thomas B Ward, Smith, & Vaid, 1997).

ASM processes are part of the basic operations that comprise normal cognitive functioning (Kahneman & Frederick, 2002). Just as emerged from the case data, there is evidence from the literature that many of the substitutions that are part of cognitive processes are transparent to the thinkers – that is, people make the substitutions without knowing that they are doing so (Kahneman, 2011). This lends weight to the opinions of some researchers that ASM processes – analogical thinking – is at the heart of all cognitive processing (Hofstadter, 2001).

At the computational theory level, the operation of analogical thinking is the subject of broad consensus. According to (Dunbar, 1997), analogies consist of two components, the target and the base. The target is the concept that is being explained, and the base is another concept which has some structural relation to the target. In order to construct an analogy, features of the base are mapped onto features of the target. While targets and bases may be more or less distant – that is, have varying degrees of similarity – this act of mapping can add insight into the nature of the target by extending the analogy: mapping additional features from the base onto the target. Dunbar (1997) found that scientists, in the creative process of developing theories, used analogy both as an ideation tool and a communication tool.

### 7.7.4 Structure

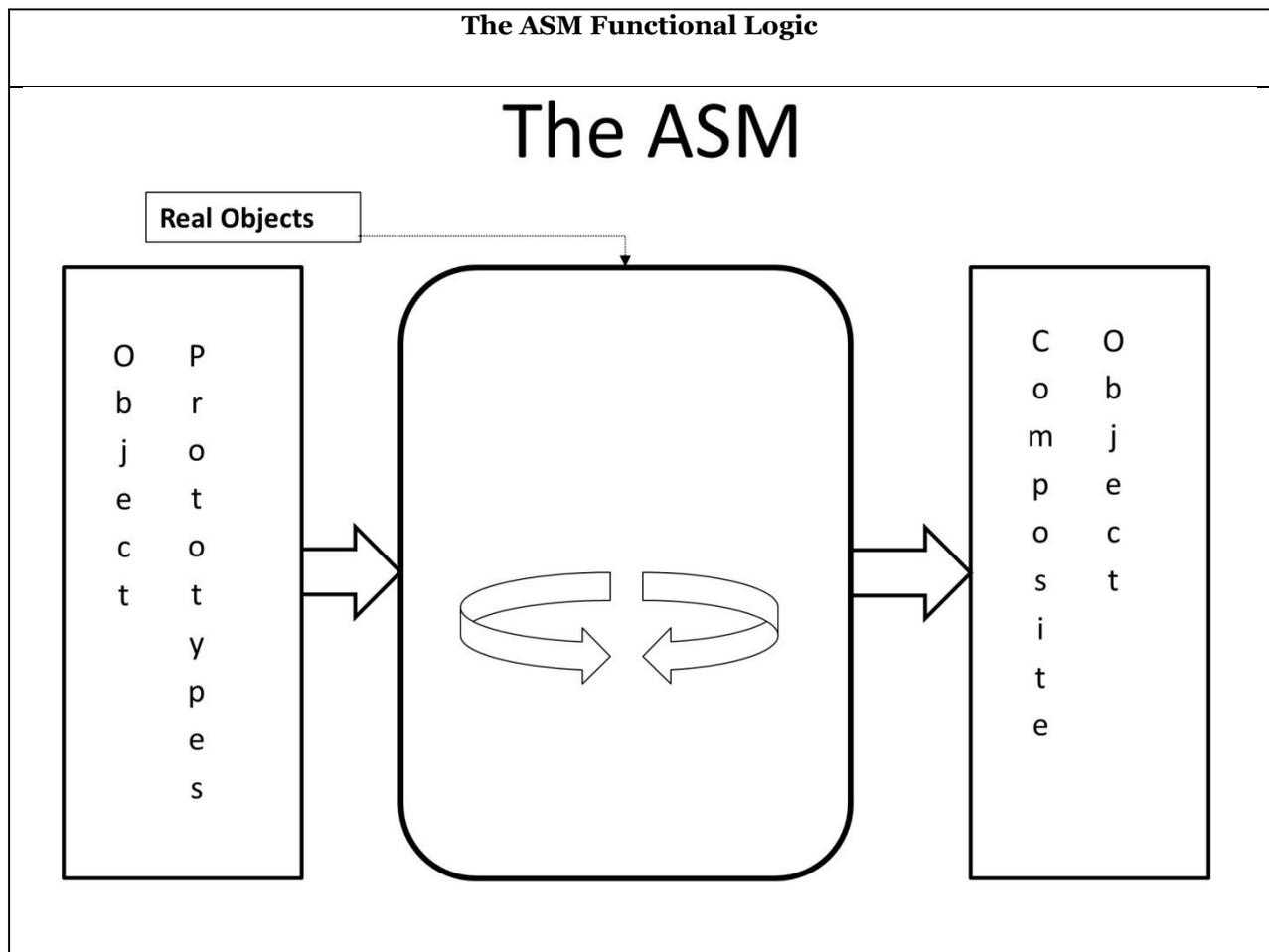
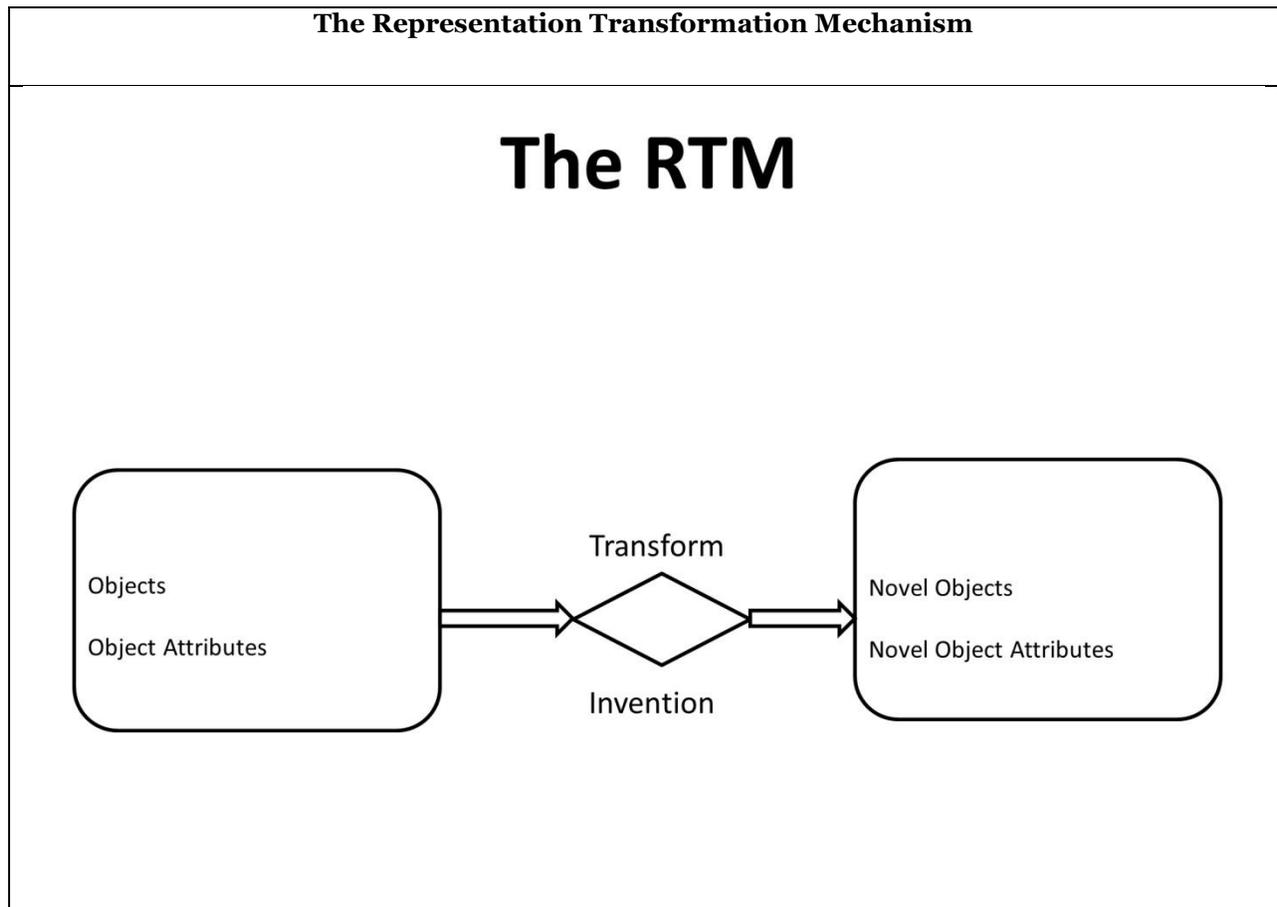


Figure 18: The ASM Logical Structure

### 7.7.5 Conditions

- Enabling Conditions
  - Existing exemplars
  - Similarities between base and target
- Stimulus Conditions (triggers)
  - Requirements for reconfiguration
- Releasing Conditions (remove impediments)
  - Proximity of target and base

## 7.8 The Representation Transformation Mechanism (RTM)



**Figure 19: The Representation Transformation Mechanism**

According to Leslie (1987) there are three types of operation which are key parts of the simulation process which takes place in the SR. They are:

- *Object Substitution*: Making one object stand in for another
- *Attribution of Pretend Properties*: Modeling properties for objects that do not correspond to reality
- *Creating Imaginary Objects*: Inventing objects that are not there

Two of these three operations are handled by the Representation Transformation Mechanism (RTM) which is a type of the Serial Structuring Mechanism (SSM).

These are:

- Creating imaginary objects

- Attribution of Pretend Properties; IFF those properties are *invented*

It is described below.

### 7.8.1 Description

Another aspect of the simulation process that takes place in the Secondary Representation is generative, it can be thought of as *inventive thinking*. It represents the development of novel objects, object properties or action sequences through a process of mental invention that does not draw on a direct precursor in the manner that objects, properties and sequences generated by the Attribute Substitution Mechanism do. This can be illustrated using some of the hypotheticals generated before. For example, where there is a jacket with the attribute `jacket_color=green`, and another jacket with the attribute `jacket_color=red`; an analogical transfer process can copy the value of the attribute `jacket_color` from one jacket to the other. Imagining that a red jacket is green can therefore be explained using the ASM. However, if I should begin to imagine that my jacket has two wings attached, which will enable me to fly, it is less likely that this image can be explained analogically, since the other jackets do not have wings attached. This can therefore be modeled as an action of the Representation Transformation Mechanism.

There is one fundamental question about the RTM that the above example illustrates: *does it actually exist?* There are views of cognition which hold that most, if not all, human cognitive activity can be explained in terms of analogical processes (Hofstadter, 2001). Holders of such views would point out – in terms of the example above – that in order to imagine a jacket with wings which enable me to fly, I would need to have preexisting prototypes for “jacket”, “wings”, and “fly”. Furthermore, my prototype for “wings” would already have the attribute “`enable_flying=YES`” because I interpret the wings as giving me that power. The example could then be seen as simply an analogical transfer of a number of preexisting prototypes into a new configuration. They could also point out that a number of cultural symbols involve objects which have a human body with a winged thorax (e.g., angels, comic book superheroes such as Hawkman, etc.), making numerous exemplars available to cue me to analogically transfer “wings” to “jacket”.

This difficulty in classifying a particular mental action as invention or analogue is broader than the present discussion. There are a number of mental feats which have been used as examples of “insight” – discontinuous generative ideation – that it has been shown can actually be accomplished via a continuous logical process (Weisberg, 1995). Ultimately, the issue goes to the unobservability of mental processes. If there are multiple possible mechanisms which can generate an outcome, and if it cannot be established by direct observation which mechanism causes the observed outcome, then the researcher must employ judgmental rationality (Wynn & Williams, 2012, p. 795).

In my analysis, I found ideation events that seem to correspond to the invention of new objects and object attributes in the simulation process undertaken by participants. While it may be *possible* to model these events as analogical transfers, I believe that modeling them as invention of the type enabled by the RTM is more consistent with current understandings of the structure of the reasoning system, and offers better explanatory power than other alternatives. I therefore posit the existence and operation of the RTM.

### **7.8.2 Case Evidence**

A number of cases in the data can be modeled as reflecting the operation of the RTM.

One is in the Beta case in which the new IT manager solved a problem with communication with the firm's customers by using a Product file as, essentially, a communication tool. This is, of course, completely different from the standard methods of using Product, which is an office productivity tool. The IT manager would have had to completely transform her internal representation of Product and invent a completely new way to conceptualize it and instantiate a new way to use it.

The above interpretation of the case data is, of course, a direct contradiction to the one in the previous section, in which the same event was used as evidence for the ASM. The fact is that this equifinality is a feature of analyses in which unobservable mental mechanisms are retrospectively applied to real-world data. Without controlled experiments, it can be difficult to identify which of a number of candidate mechanisms is responsible for a particular event. This can make retrospective attribution something of a philosophical problem: in analogical terms, does the thing developed (target) have any relation to a previous thing (base)? In real terms, it is almost impossible to identify any technological artifact that does not have some kind of structural similarity to any other thing. That said, with the application of judgment rationality (Wynn & Williams, 2012), it is possible to identify a mechanism which appears to provide a best fit between the case data and the proposed mechanism. I have concluded that the data best supports the existence and operation of a mechanism which extends representational concepts, and that this concept works better than a "stretching" of the concept of the ASM.

RTM operations (or perhaps, potential RTM operations) can be seen in a number of cases. In the Beta case, MC used the modifications to the ordering process using a custom Product file as a way to move responsibility for the ordering process away from IT and onto the sales department. Whereas he could have made incremental changes to the system in order to make it more efficient, he used the modifications of the system as a way to accomplish a larger goal. The same thing can be said about some design elements of the Mobile Data system in the Gamma case. For example, one of the benefits of using the store-and-forward capabilities of the Mesh software is that it can streamline data aggregation. Since all it need to move data is for one Mesh-enabled phone to be within range of another, one idea for collecting data in a disaster zone was to fly a model airplane with a phone attached above areas that are

otherwise cut off from communication. This would be a totally new method of collecting data, and is enabled by the combination of the component modules of Mobile Data.

### 7.8.3 Literature

The RTM fundamentally describes the ability to solve problems through a transformation of the problem space within which the problem lies. Unlike combinations of concepts which are typical in the operations of the ASM, this transformation involves making leaps of knowledge from a present state to a new state. It is symmetrical with the form of creativity that Thomas B Ward et al. (1997) describe as “conceptual expansion”, and what Boden (1996) described as “transformation of conceptual spaces”: inventing new ideas by transforming the rules of an established structured system of thought. One debate in the literature concerns how this transformation typically happens.

The process of moving from a state in which a problem solver who does not know how to solve a problem suddenly moves to state in which they do know how to solve it has been termed *insight* in the literature (Mayer, 1995). Insight is associated with what is popularly known as the “ah-hah” moment: inexplicable, sudden knowledge of the solution to a problem. Often the individuals who experience these sudden revelations are not able to explain or describe the process by which they become available. This has led some to describe the “moment of insight” as involving a “sudden illumination” which is not predictable and cannot be scientifically explained (Metcalfe, 1986).

However other studies have shown evidence for “non-conscious incubation”, in which a structured reasoning process takes place during the solving of insight problems which is much like a conscious reasoning process; except for the fact that the subjects do not have conscious awareness of the process (Weisberg & Alba, 1981). Further, it has been shown that many of the problems commonly used as experimental conditions in studies of “insight” are actually solved through a sequential reasoning process, rather than a sudden state-change (Weisberg, 1995).

The evidence leads R.K. Sawyer (2012) to conclude that the “moment of insight” is the result of a structured reasoning process that is only partially available to conscious awareness. This process is facilitated by the possession of relevant domain knowledge, and can roughly be equated to a structured creative process where the acquisition of the necessary background information has been completed before the presentation of the problem (Fisher & Amabile, 2009).

## 7.8.4 Structure

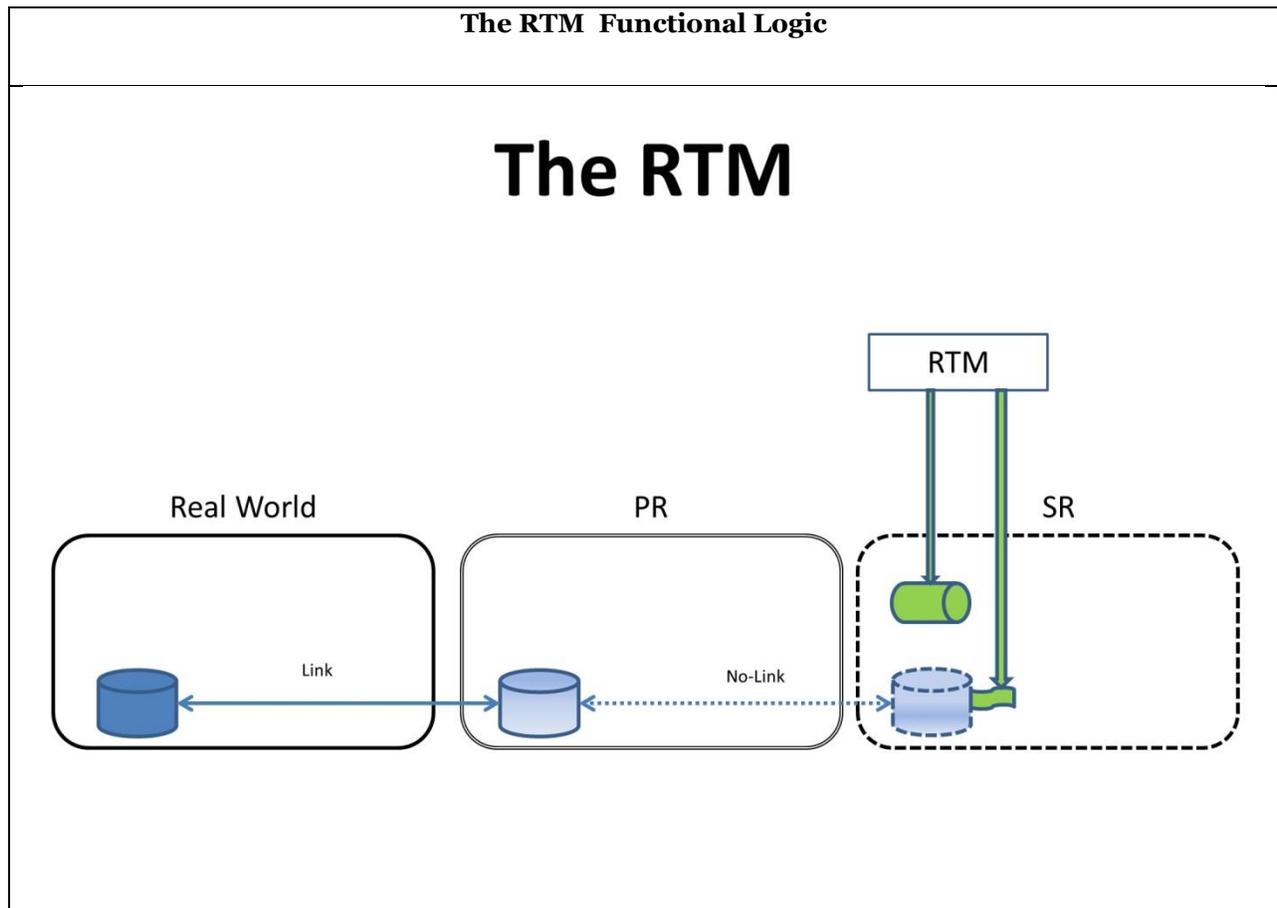


Figure 20: The RTM Logical Structure

The RTM adds (and, potentially, removes) objects and attributes from the Secondary Representation in ways not semantically linked to objects and attributes in the Primary Representation.

## 7.8.5 Conditions

- Enabling Conditions
  - Knowledge of problem space
- Stimulus Conditions (triggers)
  - Lack of contiguous routes to solutions
- Releasing Conditions (remove impediments)
  - Simulation conditions

## 7.9 The Concrete Transformation Mechanism (CTM)

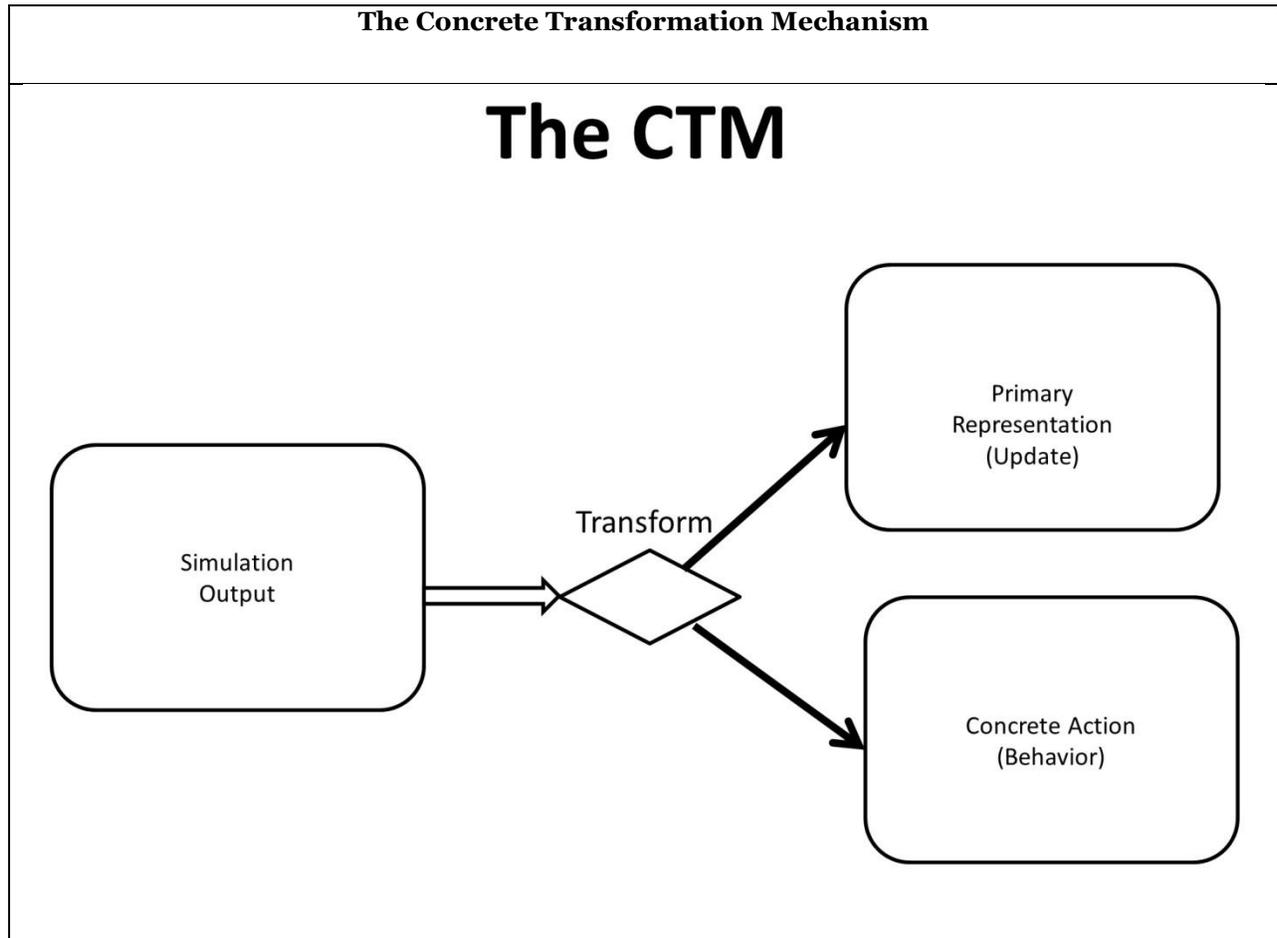


Figure 21: The Concrete Transformation Mechanism

The Concrete Transformation Mechanism (CTM) – which is a type of the Serial Structuring Mechanism – takes the output of a simulation from the Secondary Representation, and copies it over to the Primary Representation. The output of the simulation will be an ‘alternate world’ which represents the stimulus response that has been selected as optimal. The CTM will then initiate concrete actions to be performed on the real world in order to change the state of the real world to match the state of the simulation output condition, typically through activation of what Card et al. (1983) refer to as the motor system.

### 7.9.1 Description

The Decoupling Mechanism initiates a cognitive simulation process which enables the evaluation of different “alternate worlds”, in which the consequences of different possible stimulus responses can be simulated and evaluated. The output of the simulation process will represent a possible “alternate world”,

a simulated stimulus response which represents one possible route to the desired goal-state. This can be referred to as an *idea*. In order for this idea to be implemented, some kind of behavior, such as performing an action, verbal expression, or engaging in social interaction, will be necessary. Carrying out behavior is not possible from the Secondary Representation. Since the SR is a “quarantine” in which mental simulations can take place without representation abuse in the PR (Leslie, 1987), the SR is also quarantined from those mental structures that can initiate behavior. An idea (i.e., simulation output) from the SR must be copied over to the PR in order for it to result in external action. The simulation output must then be transformed from purely mental representations to signals that will actuate the motor system (Card et al., 1983). This copying and transformation is done by the Concrete Transformation Mechanism (CTM).

The operations of the CTM are what we are usually talking about when we talk about *skill*. For example, the finding by Ericsson et al. (1993), popularized by Gladwell (2008), that a certain amount of deliberate practice is necessary for expertise in most domains of knowledge (the “10,000 hour rule”), describes the development of efficiencies of sub-mechanisms within the CTM. These sub-mechanisms are domain-specific, there is little evidence that systematic practice in one domain can yield increased performance in others (S. B. Kaufman, 2009). Intense, deliberate practice appears to have two effects: one is physical conditioning, and the other an encoding of action sequences from System 2 into System 1, so that elements of performance in the domain become part of the Tightly Compiled Learned Information structures in System 1 (Ericsson et al., 1993; Stanovich, 2011).

However, to describe the CTM as the development of motor skills would understate the diversity of the processes that the mechanism subsumes. Many creative actions require the coordination of efforts of a number of different individuals, or collective actions. At the individual level, triggering these collective actions may involve communication skills, political skills, and other, less easily defined qualities such as “leadership ability”. Individuals may have to develop shared representations and goals through communication process within their own group and then negotiate with other groups within an organizational hierarchy to implement their goals. The CTM involves all these related processes.

Although the CTM initiates action to change the state of the world to match the optimal output of the SR simulation process, this does not imply that the action will necessarily succeed. Changing the state of the real world may fail because of a disconnect between the state of the world and the state of the PR (which was copied). Or it may fail because of a previously unknown property of the real world that becomes apparent when changing it is attempted. Or it may fail for some other reason. If it does fail, the PR will be updated with the state of the world’s lack of change by the RCM; the new state, along with any information that was gained during the failed attempt, will be copied and decoupled; and the cycle will continue, until it is terminated.

Collectively, the CTM encompasses what groups do when they take action to accomplish goals. In an organizational setting, CTM operations correspond to activities such as product development and project implementation, where strategic plans are put into action.

### **7.9.2 Case Evidence**

In its broadest sense, the CTM describes the ability of actors to take action in order to implement ideas. Therefore, in the broadest sense, all the actions taken by actors in the case data represent the operation of the CTM. Manipulating the physical properties of a technical object, engaging in a collaboration, managing a team, and negotiating with a number of suppliers, all represent different actions that are part of the CTM.

Specific competencies and skills exhibited by certain actors in each of the cases represent instances of activation of the CTM. For example, the technical skills applied by MC in modifying the Product file are part of the application of the CTM in that case. In the Zeta case, the skills applied by RF in creating a modular modification for the university's LMS in order to create PythonCode represent illustrations of the CTM. However the CTM processes that drive a creative appropriation incident do not necessarily involve technical skills or require direct appropriation of technology. For example, when MP negotiated with the manufacturers of Tracker in order to get their cooperation with Mobile Data, he was engaging in a specific type of CTM activity that requires skill, but involves no direct interaction with a technology artifact.

It should also be noted that in the case data, CTM activities were not simply part of the implementation of ideas, but also an intrinsic part of learning and planning. For example, in the Alpha case, trying to develop different solutions for replacing the Desktop application involved CTM processes. Through those processes, it was discovered that no available application met Alpha's needs. The developing and testing of a prototype by DL was also a CTM process. These processes were a part of the larger overarching process of developing a solution, which I am defining as a "case" (note that the "case" could look very different if another arbitrary decision about scope were made and used to analyze the same data (Leonardi, 2011)). However, learning from each attempt, and adapting the approach to the problem in response to that learning, involved every mechanism.

While each mechanism describes a coherent logical action, the contribution of each mechanism to the creative process cannot be understood in isolation from the others. This fact will be revisited later in this chapter.

### **7.9.3 Literature**

Engaging in concrete actions may seem like a conscious step in the creative process, but in fact, like all the other processes, it depends on, and includes, many aspects of System 1. Often individuals are not

conscious of the extent to which their skills draw on non-conscious resources. For example, Snyder, Ashitaka, Shimada, Ulrich, and Logan (2013) demonstrated that many skilled touch-typists are unable to accurately identify all the keys on a standard qwerty keyboard. When they then gave them a training session on the Dvorak keyboard (which none of them had used previously), they found that, although the typists learned to use the keyboard, they could not accurately describe the key placement. In the same way, artists with fully-developed ideas for a product (such as a sculpted piece), are often unable to verbally describe those ideas (Moeran & Christensen, 2013, p. 129).

This reinforces the point that everyday cognition and behavior is highly dependent on both System 1 and System 2. The CTM will, within each domain of creative action, represent an ensemble of skilled performance mechanisms which operate at both conscious and unconscious levels within individuals (Kahneman, 2011). The CTM will also be responsible for the communicative and coordinative actions which initiate and sustain collective action at the distributed cognitive level (Dunbar, 1997).

Simon (1980, p. 40) calls this part of the cognitive system an *interface*: it translates between the internal environment of the system – where cognitive representations of objects in the world are manipulated – and the external environment – in which real objects in the world are manipulated through actuation of the sensorimotor system. He notes that the problem of communicating between these two worlds is perhaps the most delicate in designing an artificial adaptive system. Progress has been much faster in designing systems which replicate the processes in only one of these worlds (mechanical systems and information-processing systems) than those which replicate processes in both (interactive “intelligent” robotic systems).

### 7.9.4 Structure

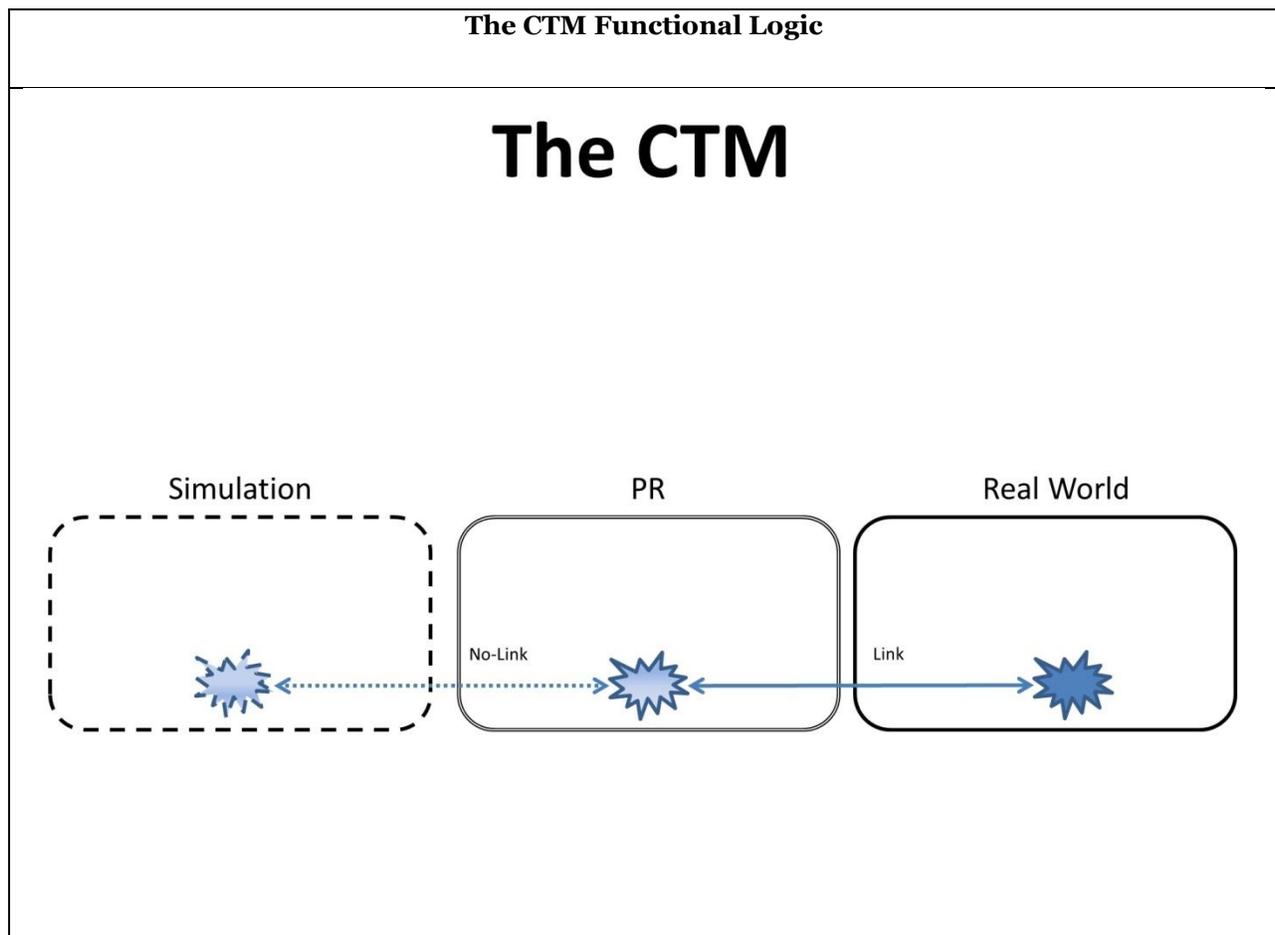


Figure 22: The CTM Logical Structure

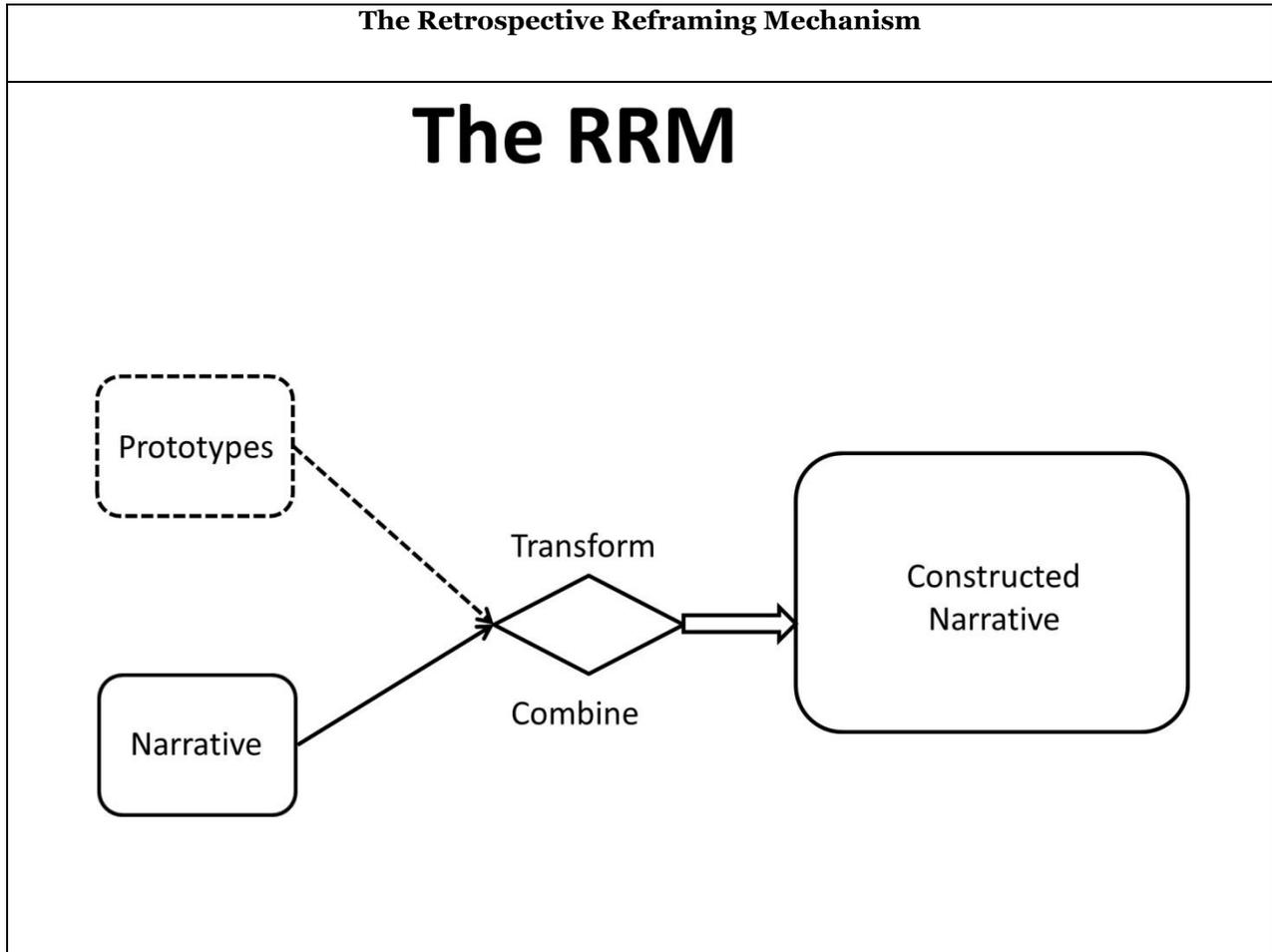
The CTM “concretizes” abstract simulation outputs from the Secondary Representation, by copying them to the Primary Representation, and converting them into actuations of the motor system that result in real-world behavior.

### 7.9.5 Conditions

- Enabling Conditions
  - Preexisting TCLI modules
  - Assorted domain-specific practice effects
- Stimulus Conditions (triggers)
  - Simulation output from SR
- Releasing Conditions (remove impediments)

- Fully-formed simulation outputs

## 7.10 The Retrospective Reframing Mechanism (RRM)



**Figure 23: The Retrospective Reframing Mechanism**

At the same time that the cognitive system is carrying out steps to transform the world, it is also creating a representation of its own activities. This representation is created by the Retrospective Reframing Mechanism (RRM). The RRM – which is a type of the AAM – takes as input incomplete narrative information about the creative actions being taken. It also takes as input prototypical information about the objects, processes and concepts which are involved in creative action. It transforms the incomplete narrative information by combining it with the prototypical information, creates a constructed representation of the creative process, and writes it to long term storage.

The RRM is elaborated below.

### 7.10.1 Description

When individuals or collectives engage in creative activities, they store representations of the events that comprised those activities to long-term storage – whether in the form of memories, or in the form of spoken narratives, written accounts or other formal records. However, there is a well-documented tendency for those accounts to be, not only incomplete, but also systematically biased. Both at the individual and small group (Dunbar, 1997), and at the societal and historical levels (Schaffer, 1994), accounts of creative events tend to be constructed which are not only false, but systematically confabulated according to recognizable patterns. Specifically, certain tropes like the ‘lone inventor’ and other myths about creative individuals and the creative process which have been repeatedly disproved by empirical research remain prominent in cultural explanations of creative events (R. K. Sawyer, 2007; R.K. Sawyer, 2012). Events consistent with this were observed in the case data and it is explained by the Retrospective Reframing Mechanism (RRM).

The basic function of the RRM is to write accounts of events to long-term storage. It takes narrative accounts of events – whether gathered from the sensory apparatus, narrated stories, documentary accounts, or other sources – and writes them to neuronal or non-neuronal long-term media. At the individual cognitive level, this is an automatic process that is performed by System 1 (Kahneman, 2011). This process has a tendency (Wynn & Williams, 2012) to build representations which are *associatively coherent* – that is, logically consistent with preexisting knowledge structures (prototypes) and structurally comprehensive. Received information about the world is always incomplete. The RRM achieves associative coherence and comprehensiveness by combining preexisting prototypical narratives with the incomplete narrative information it receives. The result of this combinatorial process is the formation of memories which are subjectively complete, but are in fact, partially confabulated.

The prototypes which are read by the RRM differ by the level of cognition. At the System 1 level they are cognitive schemas. At the System 2 level, they are stereotypical beliefs. At the distributed cognitive level they are archetypical objects, distributed through communication artifacts such as documents. At each level, the output of the mechanism is also different. At System 1, the output is reinforcement of the schema, at System 2, stereotypes become entrenched beliefs, at the distributed cognitive level, the output becomes shared representations in the form of written records, spoken narratives, etc. Also, at each level, each input reinforces the other.

The RRM explains why myths about creativity that have been well refuted remain current in social discourse and continue to shape our conceptions of creative people and actions (R. K. Sawyer, 2007). However, like the other mechanisms, it also has broader implications, since it reflects deep underlying tendencies, rather than some process which is unique to creative behavior (Weisberg, 1995). It suggests

that, like decision making (see Kahneman and Klein (2009)), the process of memory formation may require further study in order to understand the conditions under which individual perceptions and self-reports are and are not reliable measures of actual events.

### **7.10.2 Case Evidence**

Since the primary source of data for each case was semi-structured interviews with participants who had taken part in the incident, all the cases can be expected to have been influenced by the RRM. This problem of the subjectivity and distortion of reported accounts is a well-known limitation of interview data (Dunbar, 1997), and is also a problem with quantitative self-report data (Straub et al., 1995). This kind of narrative distortion is often attributed to conscious effects such as social desirability bias, but is often an effect of confabulation by the cognitive system (Evans, 2009). Often, the effects of this confabulation are transparent, and undetectable. In this study, there were a few incidents in which the effects of the RRM may have been made visible.

In the case data, there were indications of the operation of the RRM in several instances where participants seemed unaware of relationships that were visible in data they had supplied. For example, in the Gamma case, the consultant, KF, did not seem aware of the fact that his idea for using mobile phones as file servers in disaster zones was quite similar structurally to the fundamental idea behind Mobile Data. Interestingly, MP, who was the main driver behind the Mobile Data project, did not seem aware of the similarity either. In such a case, it is often true that there are multiple possible explanations for the observed facts. For example, it might be assumed that KF was aware that he was inspired by Mobile Data, but was withholding that information in order to take full credit for the idea. However, my observations of KF, MP, and the collaborative spirit of the members of the Mobile Data team that I met and interacted with, makes me doubt that this is the case. It is also possible that KF may be completely accurate — maybe his idea is completely unconnected to Mobile Data and was not inspired by it in any way. Since it is not practical to directly observe cognitive processes, this possibility cannot be disproved. However, applying judgment rationality, the most likely explanation appears to be that KF was inspired by the Mobile Data idea (which, it must be noted, he made substantial contributions to), and that he is not aware of it because of the operation of the RRM.

A similar explanation for the genesis of the order book case in organization Beta by the IT manager RR also makes sense. RR was facing a problem that was structurally similar to the problem that the production department was trying to solve when they developed the system for communicating with the factory using Product. As a new manager, RR would have been familiarized with the existing systems in Beta, and would have been briefed on the background of spec sheet system. It seems most rational to assume that — either consciously or non-consciously — she was inspired by the spec sheet system to create a similar system using Product to communicate with customers. However, that idea does not appear to have occurred to any of the participants who I interviewed about the incident.

It should be reiterated that the RRM is always at work. Discrepancies in data can make it visible, but without it the data itself would not exist.

### 7.10.3 Literature

At the individual level, the effects of the RRM can be seen in the body of literature that reflects the human tendency to misremember narrative events. Apart from generalized memory decay over time, there is substantial evidence that the ways in which memory errors happen are systematic. An example of this is in Redelmeier and Kahneman (1996), which demonstrated that memories of a painful treatment – in this case, a colonoscopy – were systematically incorrect. Specifically, they found that the peak intensity of pain, and pain during the last 3 minutes of the procedure, determined their memories of the intensity of the experience. Patients' memory of the intensity of the procedure was not determined by total pain in terms of the time experienced – *duration neglect* – but rather by those metrics – the *peak-end rule* (Kahneman, 2011). Patients who had clearly suffered more in terms of pain over time could be made to have less intense memories of the procedure.

At the collective level, Schaffer (1994) showed that many stories of creative discoveries were systematically confabulated, rather than direct reflections of the actual narrative. The tendency to systematically confabulate the origin stories of scientific discoveries is one of the major themes in the sociology of science, and has been explored by Stigler (1983), Merton (1957), and others. In fact, the prevalence of the phenomenon led Stigler to propose Stigler's Law of Eponymy (Stigler, 1980), which states, succinctly: "No scientific discovery is named after its discoverer." Stigler credits Merton with the idea, thus making Stigler's Law an example of Stigler's Law. The tendency has also been noted in many other domains, and has been the basis of challenges to the structure of the patent system (Lemley, 2011).

The tendencies noted above give some indication of the way that the RRM operates. It collects incomplete information about the narrative event being stored (such information always being incomplete). It then compresses that information using rules (such as the peak-end rule), with a tendency to designate events as types of a category. The implications of these tendencies will be explored in the next chapter.

### 7.10.4 Structure

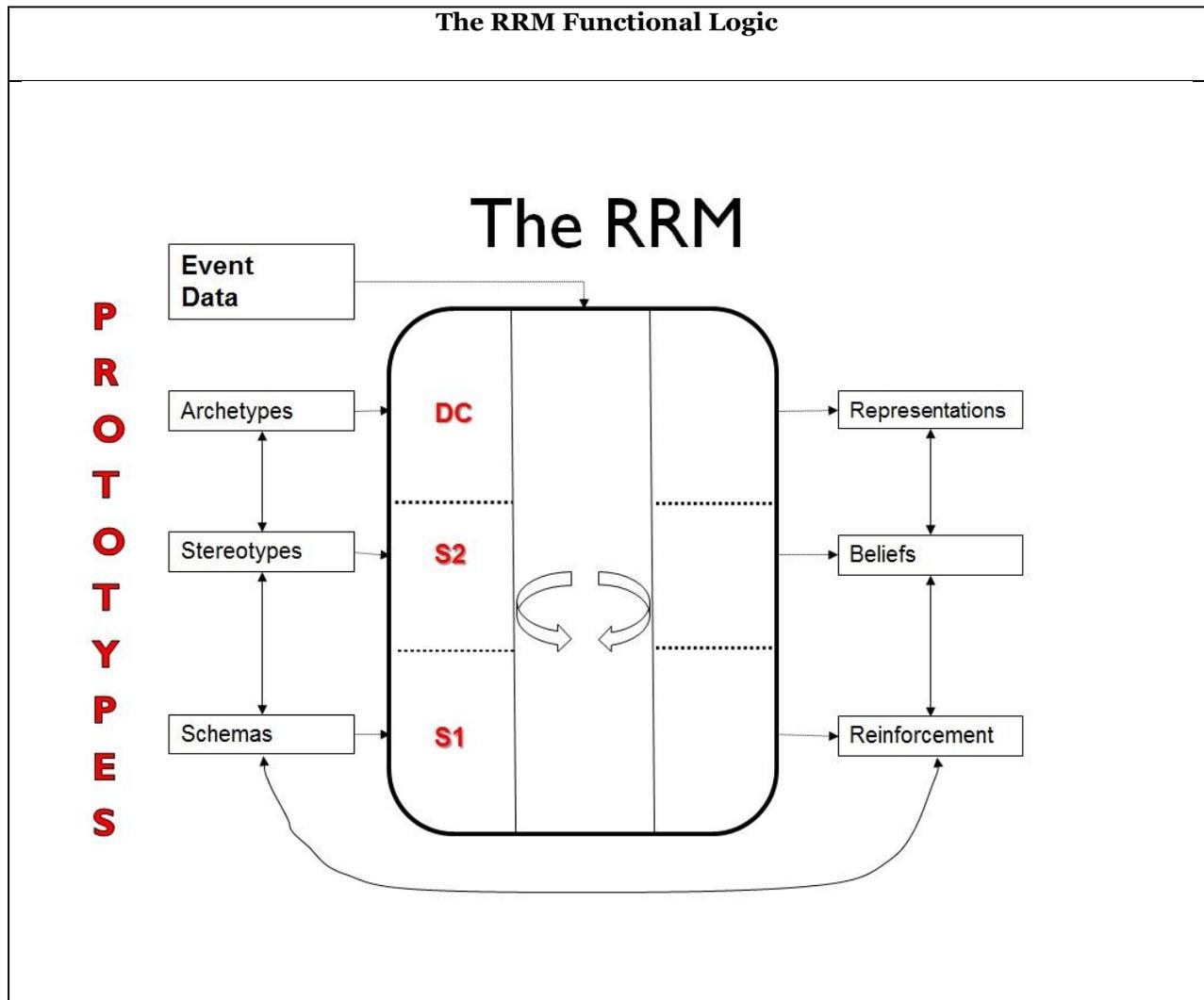


Figure 24: The RRM Logical Structure

The RRM takes as input raw event data, from sensory inputs and other data sources (narrative accounts, etc.) It also takes as input prototypical representations of how the event is expected to unfold. The input prototypes differ at each level of cognition: schematic memory structures at the S1 level, stereotypical beliefs at the S2 level, and archetypal representations at the DC level. These are combined with the event data to form the constructed representation of events that is written to long-term storage by the mechanism.

Because the input prototypes are partial inputs to constructing the story, they will *tend to* influence the story in such a way that they are reinforced (i.e., actors will tend to remember an event in ways that conform to the prototypes they access). The prototypes at each level also tend to reinforce the prototypes

at other levels (i.e., stereotypical beliefs will tend to influence the formation of subconscious schemas and will also tend to influence the narratives that are created at the distributed level).

### 7.10.5 Conditions

- Enabling Conditions
  - Any narrative to be stored
- Stimulus Conditions (triggers)
  - Multidimensionality of information
- Releasing Conditions (remove impediments)
  - Preexisting prototypes

## 7.11 Integrating the Mechanisms: The Information Cycle Model

It has previously been noted that each mechanism cannot be understood in isolation from the other mechanisms. In order to have full explanatory power the mechanisms must be seen as working together as a system. In this section, I describe that system. In concordance with the scope of the thesis, I describe the operation of the system at the individual level only.

Mechanisms are an inherently hierarchical concept (Hedström & Ylikoski, 2010), as they both imply mechanisms at a lower level, and comprise mechanisms at a higher level. The critical realist assumption of *emergence* means that a description of a mechanism need not include a description of each of its component mechanisms. However, to explain creative appropriation from the perspective of the mechanisms identified in this study, it is necessary to explain how they function together at a superordinate hierarchical level. Bringing the mechanisms together at this level gives a model of creative action that I have labeled the **Information Cycle Model**. It is visualized below:

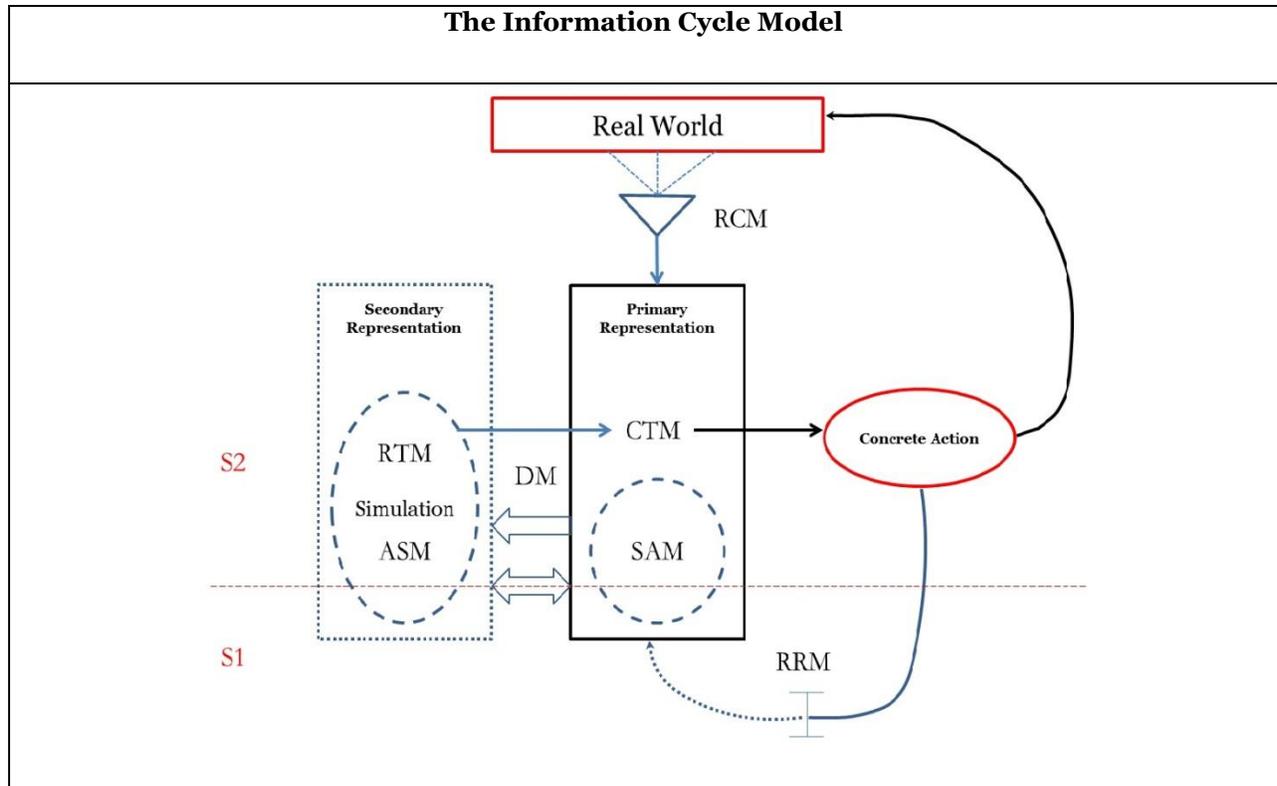


Figure 25: The Information Cycle Model

This model shows a cycle of information flows and transformations that occur during the conception, development and implementation of a creative away of appropriating an IT system. The cycle begins with the perception of a need to change the way a system used from the “normal” way of using the system, to a novel and useful way that does not yet exist. Information flows into the cognitive system through the RCM, which combines signals from the sensory system with prototypes to form a Primary Representation. “Normal” or routine methods of using the system are handled by the SAM. However, at some point, the need for a novel way of using the system to be developed results in the triggering of the DM. The DM creates a copy of the information in the PR – a Secondary Representation – and separates that copy from the PR. Within the SR, a process of Simulation takes place: the objects, object properties, and scripts within the SR are manipulated by the ASM and RTM until the simulation develops an alternate model of how the system can be used that will result in the desired goal-state. This model of the “alternate world” – i.e., the new way of using the system – is copied to the PR and translated into a series of concrete goal-directed actions that will act on the external world to transform it to state of the simulation output by the CTM. These actions may be successful, or they may fail; in the case of a complex new way of using a system, they may also be partial or exploratory. Information about the effect of the actions will be contained in signals from the environment, which will be brought into the system through the RCM; the PR will be updated with the new information, and the SR will be updated with the new state of the PR, the

simulation will be updated, and the cycle will continue. While the cycle continues, a narrative account of the operations of the system is constructed by the RRM.

The model is called “Information Cycle Model” because creative action requires cycling between ideation and enactment. For example, in the Alpha case, the novel way of using Wiki technology was not developed in a single step. There were a number of intervening steps, failed attempts, trials and intermediate developments before the full new system was developed. The process of development was iterative, and did not proceed through a set of planned stages. Like Baer and Kaufman (2005) (amusement parks) and Sternberg and Lubart (1991) (investment), I propose a well-known phenomenon to act as a metaphor for the way the system works. I propose that this integrative model is like an electrical circuit. The flow of information within the system is not a “process” with a set of well-defined events that occur in a causal chain, rather it is a continuous cycle of information that “powers” the creative process by performing work iteratively. This cycle itself can be seen as cycling between ideation and enactment: an internal transformation of the PR through a simulation process (ideation); and an external initiation of a series of concrete actions to attempt to implement the outcome of the ideation process (enactment). The cycle continues until the attempt to implement a creative idea succeeds, is terminated (e.g., by distraction) or fails; with each failure presenting an opportunity to give up, and redirect attention elsewhere, or to retry. To terminate the attempt, the “circuit” must be broken. The “circuit breaker” is the DM: if the DM ceases to operate, the simulation collapses and the cognitive system goes back to routine SAM operation.

The cycling of information can also be seen in terms of the cycling of information transformations between the “outer” and “inner” environments of the cognitive system. The transformations developed in the inner environment – represented by the action within the secondary representation executed by the ASM and RTM – are then executed – via the CTM – in the external environment. The results of that external manipulation feed back into the system through the RTM and become the basis for further simulation. In this way, the “creative” solution to a problem – and the motivation for creative appropriation is typically a problem – is developed, tested and deployed iteratively. It should be noted that this iterative process very much resembles that which is modeled in Finke et al. (1992)’s model of the internal process by which creative products are developed in the individual mind. In this way, the IT artifact serves as an interface for the iterative development of ideas between the external world and the internal “world” of the simulation within the cognitive system (Simon, 1981, pp. 7-8).

In the mind we manipulate representations of objects in the world. Technological artifacts are themselves representations of task domains (Burton-Jones & Straub, 2006). By appropriating (constitutively using) a technology, we transform existing representations into new ones (Burton-Jones & Grange, 2012), enacting a cognitive transformation in the world in order to make it a distributed cognitive transformation. The Information Cycle Model describes this cognitive transformation, which makes use of

affordances provided by the technology itself, as well as elements of the environment, in order to effect this transformation.

The individual mechanisms that make up the Information Cycle Model are summarized in Table 4. The implications of each of these mechanisms, and the integrative model itself, will be explored in the following chapter.

**Table 8: A Summary of the Individual Mechanisms**

<b>A Summary of the Mechanisms</b>			
<i>Name</i>	<i>Acronym</i>	<i>Type</i>	<i>Logical Operations</i>
Representation Construction Mechanism	RCM	AAM	Input: Incomplete information about the state of the external world Input: Prototypical models of state of the world Output: Primary Representation (PR) of the world
Serial Associative Mechanism	SAM	N/A	Input: Current state of PR Output: New state of PR
Decoupling Mechanism	DM	N/A	Input: Reads state of PR Output: Copy of PR – Secondary Representation (SR) Output: Maintains Separation of SR and PR
Representation Transformation Mechanism	RTM	SSM	Input: Reads state of SR Output: Updates state of SR with <i>created objects</i> and <i>created object attributes</i>
Attribute Substitution Mechanism	ASM	AAM	Input: Reads state of the SR Input: Reads existing representations of objects and attributes Output: Updates state of SR with <i>substituted objects</i> and <i>substituted object attributes</i>
Concrete Transformation Mechanism	CTM	SSM	Input: Reads output of simulation process from SR Output: Updates PR with simulation output, AND Output: Enacts concrete actions to convert external world to the state of the simulation output
Retrospective Reframing Mechanism	RRM	AAM	Input: Incomplete information about creative process Input: Prototypical models of the idealized creative process Output: Constructed representation of the creative process

## 7.12 Discussion

It should be noted that the findings in this study conform to what R.K. Sawyer (2012) described as the “business-as-usual” creativity hypothesis. There is no “creativity mechanism” which is unique to the creative process. The mechanisms identified here are all part of the regular cognitive system – at both the individual and collective levels – and can be assumed to be active in many spheres of cognitive activity. This is consistent with prior research (Dunbar, 1997), and suggests that the mechanisms may be useful for

explaining other phenomena, beside creative appropriation. It should also be reiterated that the integrative model presented is in concordance with the scope of the thesis: that is, it explains user creativity at the individual level. Although each mechanism is specified at both the individual and collective levels, I do not make the claim that the integrative model for collective action may not be different from, and perhaps be a superset of, the model for individual action. That is a matter for future research.

A pattern emerges across the operation of all the mechanisms identified here that is consistent with previous findings: the tendency toward effort minimization on the part of the cognitive system. People are cognitive misers in that the brain is designed to expend as little energy as possible on each cognitive task (Kahneman, 2011; Stanovich, 2011). Simon (1956) identified this tendency before we had current models of the mind which can explain the mechanisms which underlie it. The general implication of this is that people will default to the least cognitively expensive processing option available when responding to any stimulus condition. The least cognitively expensive response to any stimulus will always be the System 1 response, which is generated automatically. Some stimuli, however, such as those which require complex processing to be recognized, do not have a System 1 response and will trigger System 2. However, different System 2 processes have different levels of expense, and the default option will always be the least expensive.

This tendency to default to the least computationally expensive method of processing can explain many specific observations about general behavioral tendencies. It is now widely accepted that many of the judgment biases commonly shown in decision-making research are reflections of System 1 tendencies, which are drawn on to support complex reasoning processes (Kahneman, 2011). The fact that less-expensive System 2 reasoning systems are available — and are commonly defaulted to — can help to explain the effects of *habit* and *automaticity* in utilization studies in IS. For example, Polites and Karahanna (2013) cite the effects of habit in describing some actions which do require some conscious awareness and cannot be entirely attributed to System 1. The SAM provides a way of modeling the effects of these less-effortful-but-still-conscious processes that are at work in the performance of familiar, non-challenging cognitive tasks that are either inherently uncomplicated or are well supported by tightly compiled modules of learned information (TCLI) in System 1.

The set of mechanisms described here provide the ability to explain the cognitive operations that are engaged in by the participants in a creative process during that process. They do not require, but are compatible with, many “stage” theories of creativity (see R.K. Sawyer (2012) for one such). At different points in the creative process (and creative discovery is always a process, even when it seems instantaneous (Fisher & Amabile, 2009)), all the mechanisms will be active, but different mechanisms will shape the story. At the beginning, when the problem is first encountered, the RCM might be critical in deciding how it will be understood and framed. At a later point the DM might be critical in determining

whether the cognitive system attempts to find a solution to the problem. During the simulation process, the ASM might be critical in finding a key relationship between the problem at hand and a previous problem, which hints at a solution. When an idea has been generated, the skills that are part of the CTM might be critical in the attempt to implement that idea. If that attempt fails, the RCM might be critical in understanding why it failed, and setting the stage for a second attempt. And so on.

Of course, the precise sub-mechanisms by which each of these things is accomplished will vary from case to case. The benefit of specifying the mechanisms solely at the Computational Theory level (Marr, 1982) is that they form a set of general structures that can be used to understand similar processes across cases while enabling the analysis of the components of those structures in detail in any case. The mechanisms also enable the study of creative action at the conceptual level while abstracting away the details at more concrete levels. For example, neuronal structures in the brain and social structures in a society will obviously differ, both in the Representation and Algorithms that they use, and the way those are implemented physically in Hardware (Marr, 1982). However, despite this difference at the lower levels, they can both exhibit the *same tendencies* in operations at the computational theory level. This can enable researchers to make a number of interesting observations, as well as ask interesting questions at both levels, and, ultimately, enables us to build an integrated, cumulative body of knowledge about the phenomena involved by studying the operations of the mechanism (Benbasat & Zmud, 1999).

The tendencies of the mechanisms have implications for the study of creative appropriation, and, in keeping with the “business-as-usual” hypothesis (R.K. Sawyer, 2012), the study of general creativity and other behavioral domains such as problem-solving and decision-making. Some of these implications will be explored in the following chapter.

## Chapter 8. Discussion

*The wheel is an extension of the foot, the book is an extension of the eye, clothing, an extension of the skin, electric circuitry an extension of the central nervous system.*

*McLuhan and Fiore (1967)*

*(From the HIT Lab message board)*

### 8.1 Introduction: Explaining Creative Appropriation

The theory being presented seeks to describe the mechanisms which are causally-relevant to end user creativity. It is Type II theory, according to the typology proposed by Gregor (2006). However, before discussing the integrative model's implications, it may be useful to reiterate what it is not. It is not a model of brain function – it describes mechanisms in the Real domain, not physical structures in the Actual domain. It is also not a deterministic model – the mechanisms described operate in an open system: they can fire, not fire, or be interfered with at any stage in the cycle. Also, the outcome of the process, if it completes by generating a successful real-world response, need not be 'creative', in that it may not be such that appropriate observers would rate it as creative (Amabile, 1982). The model, rather, provides a framework for understanding the basic mechanisms involved in creative appropriation and shows how they may work together to generate creative responses – if and when creative responses are generated. I also do not claim that this is the only way that creative responses may come about: the routine processes of the SAM, for example, may generate unexpected novel and valuable responses. However, I contend that creative appropriations will tend to be the outcome of a fully decoupled simulation process, and the case data supports this contention.

The model explains the phenomenon of creative appropriation by demonstrating how the identified mechanisms lead to the outcome. There are other levels of the phenomenon of creative appropriation – the algorithmic and hardware implementation levels (Marr, 1982) – which it does not address. There are also particular contextual facts which are part of any creative narrative which no generalized model can predict. However, the mechanisms identified in this project provide a foundation for asking better questions, and a roadmap for a program of research that can address long-standing questions that can illuminate not only creative appropriation, but creativity in general, as well as the study of behavior in a number of contexts. In this section I will identify some implications for creativity in general that can be inferred from the existing evidence about the mechanisms identified. These can be taken as explanations of *why* some tendencies are expected to be seen in incidents of creative action, given the tendencies exhibited by the mechanisms that generate those creative actions.

I will proceed as follows. I will look at each specific mechanism, beginning with the individual mechanisms, and ending with the integrated Information Cycle Model. For each, I will discuss some implications of the specific mechanism. I will then go on to consider more broadly the implications of the Information Cycle Model for our understanding of creative actions, the people who carry them out, and effects that they have. Finally, I will revisit some of the “open questions” that were introduced in the Introduction to this thesis, and discuss how the model addresses them.

## **8.2 Implications of the Individual Mechanisms**

I have previously argued that none of the mechanisms identified in the study can be understood in isolation. The mechanisms form a system, and explaining creative appropriation requires looking at the system as a whole. However, each of the mechanisms has its own tendencies, and therefore has certain effects on the operation of the overall system.

Before discussing the implications of the Information Cycle Model as a whole, I will briefly consider some implications of each mechanism and how those may inform an understanding of creative appropriation.

### **8.2.1 Implications of the RCM**

The major implication of the Representation Construction Mechanism (RCM) is that cognitive systems will have a tendency to systematically misinterpret the nature of the external world. This misinterpretation will be guided by the nature of the prototypes used to “fill in the details” of the incomplete perceptual information which is received about the state of the external world.

These prototypes are active at the System 1 and System 2 levels, but they are shared at the distributed cognitive level. The shared prototypes conform to Csikszentmihalyi (1999b)’s definition of a “culture” – a shared symbol system. This common symbol system conforms with Walsham (1995b, p. 75)’s concept of internal realism, an intersubjective construction of reality driven by a shared cognitive apparatus (Nandhakumar & Jones, 1997, p. 110). These common symbolic representations of idealized reality are shared at the distributed level, but influence beliefs about reality at both the conscious and unconscious levels. This may help explain why individuals share cognitive biases and use common heuristics (Tversky & Kahneman, 1974). It may also explain common errors of estimation at the collective levels, such as Hirschman (1967)’s Hiding Hand principle. It may also provide a mechanistic explanation for how disciplinary paradigms shape the work of individual scientists; and how such paradigms do so without being visible to those whose thinking they shape (Kuhn, 1996).

The notion of shared prototypes shaping the subjective picture of reality held by the cognitive system is compatible with a large variety of findings in the behavioral sciences. It provides an explanatory

framework for analyzing phenomena from social stereotyping to common decision biases. In all, the RCM strongly supports the critical realist assumption that human knowledge of reality is limited and fallible.

### **8.2.2 Implications of the SAM**

The Serial Associative Mechanism (SAM) implies that in most situations, especially those which involve low to moderate degrees of cognitive load, or executing actions which are perceived as routine, individuals will tend to default to a low-power type of System 2 processing that is heavily supported by System 1. While System 1 processes are involved in all types of cognitive activity, the nature of this processing may mean that this mode of operation is more guided by System 1 than fully decoupled cognition. This could mean that it is more guided by prototypes at the System 1 level, which may conflict with prototypes held at the conscious levels.

A particularly dramatic example of the effects of this may be seen in the “Linda” conjunction fallacy (Tversky & Kahneman, 1983b). Even subjects who were highly trained in statistics and who *knew* that it was statistically impossible for a conjunction to have a higher probability than its constituents, still *felt like* the conjunction was more probable. The primacy of the “feeling” system over the “knowing” system is hidden (even from the individuals themselves) by System 2’s tendency to confabulate associatively coherent retrospective explanations for its own behavior. This suggests that much of an individual’s everyday routine behavior is likely far less “rational” than they realize (Evans, 2009).

The SAM is efficient, and it is highly unlikely that normal cognitive functioning would be possible without it. Fully decoupled cognition is highly fatiguing for individuals who are forced to conduct it (Kahneman, Tursky, Shapiro, & Crider, 1969). If it were necessary to give full attention to each stimulus, the individual cognitive system’s capacity for response would quickly be overwhelmed. There is also abundant evidence that SAM-style processing enables individuals to function efficiently in time sensitive environments (G. Klein & Crandall, 1996), and that, in some circumstances, SAM-style processing may lead to higher quality decisions (T. D. Wilson & Schooler, 1991). However, SAM processing also implies that systematic patterns of stimulus response which may be both unexpected and difficult to measure will be a routine part of behavior.

At the collective level, the issues are largely the same from an information-processing standpoint. Collectives, be they groups or organizations, have limited attentional resources and use routines to optimize the processing of common tasks, in order to preserve resources for the tasks that require them. This leads to a certain level of efficiency in terms of resource allocation, and also leads to certain costs, in terms of information loss.

### **8.2.3 Implications of the DM**

One primary implication of the Decoupling Mechanism (DM) is that the self-motivated ‘exploration’ phase of use predicted by some purely theoretical models of IT implementation (Jaspersen et al., 2005; Saga & Zmud, 1993), is likely to tend to be rare. This is not the first finding that has challenged the so-called “stage hypothesis” (Benbasat et al., 1984), but it does take a position on that debate.

The implication of the DM, as specified, is that decoupling and simulation is triggered to avoid perceived losses or under conditions of high motivation. The DM requires ongoing stimulation to maintain the Decouple operation. If Decouple is not maintained, the simulation collapses and the cognitive system returns to the default (SAM) mode of operation. The full story, however, is complex. The high-cognitive load decoupled state is obviously a part of the ideation process, but there is considerable evidence that an incubation process, in which the problem is dropped from working memory, but associative processes that are part of System 1 continue to search for solutions, is often part of the ideation process. How this works in detail is not currently well understood (Abraham & Windmann, 2007, p. 45).

Another implication of the DM is that caution must be used in directly applying findings from lab studies of performance to estimations about real-world performance of actors in naturalistic situations. For example, in studies of reasoning and decision-making, following routine, “intuitive” decision-making modes is associated with outcomes that are biased, and lead to sub-optimal goal-satisfaction. This can lead to an impression that the literature holds that conscious, deliberate processing is inherently superior to the kind of routine-based, low-cost processing implemented by the SAM. However, it must be borne in mind that these, almost invariably preferable, outcomes due to the kind of deliberate processing that would be associated with the activation of the DM, are commonly measured under lab conditions for artificial experimental tasks.

There is considerable evidence that in real-world conditions, especially in conditions when high response speed and coordination of multiple and complex stimulus responses are critical, expert actors develop automatic, routine responses that are capable of developing highly effective responses to contextual high-pressure environments with extremely low latency (Calderwood et al., 1987; G. Klein & Crandall, 1996). However, the same decision strategies can result in biased and sub-optimal responses under lab conditions (Reyna, 2004). The fact that the efficient – and largely effective – interventions of System 1 can lead to errors in specifically constructed experimental tasks has led to a widespread – and erroneous – assumption that System 2 processing is always qualitatively “better” than System 1 processing: a fallacy (Evans, 2012a).

What does follow from this is that to fully evaluate the effectiveness of routine vs. fully decoupled processing in a real-world domain requires field investigation of cognition within that domain.

### 8.2.4 Implications of the ASM

The capacity for relational matching (Holyoak et al., 2001, pp. 2-3) is one major difference between humans as a species and other close animals. This means that one implication of the ASM could be that it represents a capability that distinguishes human cognitive systems from other information-processing systems. Analogical thinking lies under many of the most influential ideas in human society (Abraham & Windmann, 2007). For example, perhaps the most critical factor that led to the development of cognitive science as a discipline was an analogy: between human information processing and the processing performed by a computer (Holyoak et al., 2001, p. 7).

Analogy appears to function most effectively in naturalistic environments, and less so in artificial environments, such as during lab experiments (Dunbar, 2001). This may be related to the dynamics of the relationship between SAM and DM operation. Given the intrinsically associative nature of System 1, it may be that System 1 is more easily invoked in circumstances where people are not hyper attentive and conscious of their surroundings — i.e., when they are doing routine tasks in a “normal” environment, rather than unfamiliar tasks in a lab. This implies that findings from lab studies are likely to require corresponding work in the field, observing what people do and how they think in normal environments, to gain a full understanding of cognitive processes. It supports the idea of iterative “in vivo, in vitro” approaches such as that of Dunbar (1997).

The above hypothesis — that high attention may attenuate analogical thinking ability — may also be related to the constraining effects of extrinsic motivation on creativity (Amabile, 1985).

### 8.2.5 Implications of the RTM

The RTM is associated with the cognitive phenomenon of *insight*. I define insight, as does Weisberg (1995), as the cognitive restructuring of a problem that leads to a solution, rather than an affective (aha!) experience. The primary implication of the RTM in this thesis is the assertion, on my part, that insight exists. Not all theorists are convinced that that is the case. Many cognitive actions can be explained as associative processes. Some would even argue that the RTM may not exist at all — that all thought is inherently associative. I do not share that position.

It is true that many actions coded to the RTM in this study could also be modeled as resulting from the ASM. This is common in CR research and is consistent with the equifinality and multifinality that results from the open-system assumption in CR field research (Wynn & Williams, 2012). That the thesis makes this assertion means that further work on testing the nature of the mechanisms involved in the simulation process can be useful in assessing competing theories of what happens in that process. As was said by (K. D. Miller & Tsang, 2011, p. 149): “... identifying the mechanism operating in an empirical setting is an effective way of assessing competing theories of the same phenomenon.”

In this project, I have found support for the existence and operation of the RTM. However, I acknowledge that this does not falsify possible alternate accounts of the cognitive processes involved in simulation.

More work in this area is called for.

### **8.2.6 Implications of the CTM**

The CTM is primarily about doing — the exercise of agency by the individuals and collectives that “own” cognitive systems. The CTM stands for all those actions, as well as the skills and competencies involved in taking action in the world to implement ideas.

This implies that CTM processes are a significant area in which differences in background, training, and exposure can lead to differences in outcomes. An individual may have a novel, useful and surprising idea for a software feature, but is unlikely to be able to develop a “creative” product without corresponding programming skills. However, CTM processes transcend direct appropriation moves, so the individual with the idea may communicate it to a programmer. The strength of the distributed cognitive approach is that it allows these collective processes to be viewed through a similar lens to those used to explore the marshaling of individual cognitive resources.

In all, the CTM describes actions. Since an unexpressed idea is unlikely to meet a product definition of creativity, it is almost certain that any incident of creative appropriation, using the definition in this study, will involve CTM processes.

### **8.2.7 Implications of the RRM**

The most profound implication of the RRM is that it creates the possibility of memory and learning. It is important to remember the reason why the RRM is necessary. Narrative accounts contain information, and narrative accounts of fully decoupled simulation processes will typically contain a lot of information. Information is expensive to store, and to index (Taleb, 2007, p. 68). Some research has suggested that indexing costs, rather than processing speed decay, may be responsible for the slower performance of older adults on some psychometric tests (Ramscar, Hendrix, & Baayen, 2014).

One way to increase capacity to store information is to reduce the randomness and dimensionality (or Kolmogorov complexity (Kolmogorov, 1998; Taleb, 2007)) of that information. That is what is represented by tendencies of the RRM such as narrative fallacy (Nafday, 2009, pp. 192-193) (reducing the elements of events to preexisting categories), and the peak-end rule (Redelmeier & Kahneman, 1996) (reducing the dimensionality of stored information). The compression strategies for information implemented by the RRM make it possible for humans to store and manipulate large quantities of information and make use of it.

However, those strategies have some systematic effects.

The memories that are formed of events will tend to conform to preexisting prototypes. Those prototypes will be internalized from the cultural symbol system and form part of the RCM. The memories which have been shaped by those prototypes will in turn reinforce the same prototypes at the distributed cognitive level. This may explain the remarkable longevity of cultural prototypes, even after they have been disproved by fact.

### 8.3 Implications of the Information Cycle Model

Perhaps the most profound implication of the Information Cycle Model (ICM) is the role of the web of prototypes in guiding and shaping the cognitive process. Prototypical representations at the distributed cognitive level are critical inputs to the RCM — which imply that they shape our constructed representations of the world, influencing the entire cognitive process. Not only do they shape our experience of the world, but by being part of the narrative-forming function of the RRM, they shape how we learn from our experiences. These — often implicit and inherently unobservable — shared prototypes at the collective level help to shape the stereotypes and schemas that operate at the individual levels of cognition. The individual cognitions so guided, feed back into the shared archetypal representations at the distributed level. This corresponds with Csikszentmihalyi (1999b)'s conceptualization of a web of information flows between a knowledge *domain*, a creative *individual*, and a professional *field* of gatekeepers who select creative products for inclusion in the domain. Of course, in some incidents of creativity the boundaries of these roles may be less clear than in others. For example, in the domains in which Csikszentmihalyi (1999b) conducted his research — well-defined, organized domains such as those found in the arts and the sciences — it may be easy to identify a “field” and a “domain”; while in incidents of user creativity in appropriation, the test of “creativity” may simply be implicit and based on what works. Csikszentmihalyi (1999b) calls a domain a “symbol system” containing information which is part of the *culture* (the complete set of domains). Research on the effects of creative groups and collaborative webs (R. K. Sawyer, 2007; Uzzi & Spiro, 2005), can be seen as giving insight into the way in which prototypes are shared and influence the creative process. The integrative model provides a visualization of how the cultural symbol system interacts with individual and group cognitive systems, and provides a platform for future research.

Another significant implication of the proposed operation of the integrative ICM model has to do with the effect of the activational characteristics of the DM on the likelihood of creative appropriation to occur. A particularly dramatic example of this occurred in Eta, the medical device manufacturer. Eta had developed a structured program that allowed employees to make suggestions and proposals about ways to enhance working procedures, optimize processes or in any way improve how the company ran its operations. When I discovered this procedure I initially expected it would be a source of good ideas about

how the company's ICT tools might be better used. However, when I did get access to the records of the program, I found that most of the ideas were extremely context-specific and related to particular process inefficiencies that were related to single individuals. There were no instances of the kinds of user innovation that I expected the process would facilitate. It appears that, unlike product innovation — where users see developing a creative product as an explicit task goal (e.g., using a programming IDE to write software) — users will not engage in process innovation such as appropriating systems creatively; unless they feel forced to do so in order to avoid process losses.

This makes sense in light of the fact that creative appropriation goes against two ingrained tendencies — or biases — of the cognitive system: Effort Minimization and Loss Aversion. Appropriating a system creatively tends to require significant effort, and tends to create risk while having an uncertain payoff. The implication of this is that the DM will tend *not* to fire. In order to overcome that tendency, most instances of creative appropriation are triggered by perceptions of *loss* - either actual losses due to threat (as in the Gamma case, where logistic and security problems with the current systems can cost lives), or process losses due to needs that the current system cannot fulfill (as in the Zeta cases, both of which were driven by perceived process losses). This may point to a fundamental difference between the kind of creativity in which the creative actors' goal and the medium in which they are creative are symmetrical (a pianist plays the piano with the goal of becoming a creative pianist), and the kind in which the actors' goals and the medium of creativity are asymmetrical (an accountant must find a creative way to use a system in order to complete his accounts). There is considerable evidence about the way in which positive affect about the goal state can motivate the actor in the first condition, but less research exists about the second.

The implications of this for organizations that wish to encourage process innovations are far-reaching. It would suggest that such innovations cannot be expected to occur organically as a result of extended time using a system. Contrary to what would be expected from stage theories of implementation that suggest that use innovations will naturally emerge over time (Jaspersen et al., 2005; Saga & Zmud, 1993), this suggests use innovations emerge only from specific loss-perception situations. It would suggest that deliberate strategies would need to be pursued in order to encourage process innovation to happen. One strategy for fostering such innovation might be the creation of deliberate resource constraints in order to force users to find strategies for extending the ways in which they appropriate systems. This is the strategy that was pursued — albeit, perhaps unintentionally — in Phi, the cloud computing company. Because the software tool Process was widely used and under-resourced (one developer), it was widely appropriated in unanticipated ways which were novel, and useful for the persons who so appropriated it. On the other hand, the heavily-resourced Finance department, who were able to hire outside contractors to perform functions that they could not get done through their own system, did not develop ways to appropriate that system creatively, despite the mismatch between its properties and their task requirements. Another strategy might be to make process creativity an explicit goal of the organization and allocate employee

time to it, in much the same way that many technology companies have begun to allocate “innovation time” to employees.

This raises an unanticipated question about creative appropriation by users: is it desirable? Many studies of creativity assume it to be a desirable goal that ought to be pursued, and frame increasing creativity as a goal state for organizations. However the characteristics of the DM suggest that this may need to be considered carefully where creative appropriation is concerned. Given the circumstances under which it tends to occur, the question must be asked whether high levels of creative appropriation in a company may be a warning of trouble. Among the companies in this study in which no creative appropriation was observed, the companies themselves were productive and efficient. Theta, the software company, is highly successful in a very competitive industry. Kappa, the mobile surgical company, is likewise highly successful, and very innovative in its use of technology. In Phi, it was the more under-resourced internal system that was creatively appropriated to a large extent, while the flagship commercial product was not. I also noted that the IT professionals who maintained the systems were often at least ambivalent, and at times openly critical, of users “innovating” with their systems. The developer of Process at Phi once referred to the modifications as “subverting” the system. When pressed on this he explained that his prior experience was that frequent changes tended to result in ballooning complexity, and unmanageable systems. Also, the production team at Beta, the widget manufacturer, after innovatively coming up with a novel way to use Product — the office productivity system they repurposed — have continued to use the same system for almost twenty years, making only minor tweaks to improve it. Overall, from a design perspective, a tendency for a system to be used creatively may reflect negatively on the design of that system if it is not designed for a role that involves reconfiguration.

## **8.4 Integration with Existing Knowledge**

There are several decades worth of existing knowledge in the literature regarding creativity and the workings of the cognitive system. It is worth reflecting on how the Information Cycle Model (ICM) integrates with this existing knowledge, how it extends it, and what it contributes.

The information cycle model contributes to existing creativity research by proposing plausible mechanisms which explain correlational relationships which have been previously observed (Hedström & Ylikoski, 2010). It integrates with established models of problem solving (Newell & Simon, 1972) and human information processing (Card et al., 1983). For example, Card et al. (1983) proposed that the information-processing capabilities of the human mind can be described in terms of three systems: the perceptual system, which carries sensations of the external world into internal mental representations; the motor system, which actuates musculoskeletal structures to create physical actions in response to thoughts; and the cognitive system, which carries out complex information processing actions (Card et al., 1983, pp. 24-44). In the ICM model, the actions of the RCM could be seen as analogous to those of the

perceptual system, the CTM as an analogue to the motor system, and the complex activities within the representations as analogous to the contents of the cognitive system. The structurally similar activities are analogues, rather than representations. The ICM does not rely on the structures proposed by Card et al. (1983) for its formulation, but it can be seen as compatible with those structures. The ICM is therefore compatible with, but does not depend on, the model proposed by Card et al. (1983).

With reference to the components of creativity proposed by (Amabile, 1983, 1996), we can say that the *Techniques* component corresponds to the efficiency of the simulation process within the SR and the enactment processes carried out by the CTM. *Resources* contribute to the creation of affordances by enabling the user to make use of action potentials created by the technical object properties: e.g., if an user has access to relevant technical skills, she will be able to make use of action potentials offered by a complex system that would not be available to a user without those skills. Finally, *Motivation* provides the triggering stimulus for the DM Copy operation, and the ongoing stimulus for the computationally expensive Decouple operation. Without those operations, the simulation process cannot be sustained and the system reverts to routine SAM operation. This supports Amabile's statement that, of the three components, the most important is motivation (Amabile, 1996). Overall it can be said that the ICM is compatible with, but does not depend on, the componential model.

In the Geneplore proposed by Finke et al. (1992), the creative process in the mind is modeled, broadly, as iterating between a **generative** phase, in which ideas for creative action are produced through a number of ideation processes; and an **exploratory** phase, in which ideas that are generated are evaluated and compared against product constraints. The ICM follows a similar logic in terms of the iterative cycling of information between the idea generation processes that are part of the simulation process; and the enactment processes which attempt to implement those ideas in the real world. Enactment processes which often lead to reevaluation and reformulation of the ideas, just as is modeled in the Geneplore model. In one sense, the Geneplore model could be seen as a model of the sub-mechanisms involved in the simulation process. The ICM takes the general iterative structure of the Geneplore model, and applies that structure to the interaction between mental ideation and physical enactment. However the ICM does not specify the precise mechanisms by which ideation takes place except at a high level of abstraction. The ICM is therefore compatible with, but is not dependent on, the Geneplore model.

With regard to Csikszentmihalyi (1999b)'s System Model of creativity, Csikszentmihalyi proposed that creativity emerged from a set of information flows between three entities: a domain, an individual and a field. In order for creativity to occur, a set of rules is transmitted from the domain to the individual. The individual then produces a novel variation to these rules, a novel variation which is evaluated by a field. If the field judges the novel variation to be acceptable, it is added to the domain, transforming the domain and thus rendering the individual's action "creative". The ICM may specify what happens at the individual level: how the individual generates the novel variation. At the distributed cognitive level, the ICM may be

used to understand the flow of information between field, domain and individual, in the form of prototypes. The ICM therefore provides a framework which may be used to better understand the underlying processes that enable the overarching processes described by Csikszentmihalyi (1999b). However, the ICM does not necessarily describe the unfolding of those processes at the distributed cognitive level and does not assume that Csikszentmihalyi (1999b)'s model of those processes is complete. The ICM is therefore compatible with, but is not dependent on, Csikszentmihalyi (1999b)'s systems model.

The ICM also enables us to generate better explanations of creative events and patterns through knowledge of the activational characteristics of the mechanisms. For example, several theoretical stage models of system use predict that novel appropriation patterns will emerge from an 'exploratory' stage of use after adoption (Jasperson et al., 2005; Saga & Zmud, 1993). This did not happen in any of the cases in this study. We can explain why that is by looking at the activational characteristics of the decoupling mechanism, which, because of its high computational cost and the effort minimization bias of the cognitive system, has a very high threshold for activation in non-hedonic contexts. Despite this fact, however, individuals routinely undertake decoupling and simulation activities in the form of play and games in hedonic contexts (Leslie, 1987; McGonigal, 2011). Further research on why this is may offer interesting clues as to the reasons why use determinants appear to systematically differ between hedonic and non-hedonic contexts (Van der Heijden, 2004).

It can therefore be said that the ICM is broadly compatible with a range of existing models of creativity and cognitive function. It is, in general, compatible with those models: it is consistent with what they generally say about the functioning of the cognitive system and the creative process. However, it is not dependent on those models: by limiting its level of analysis to the Computational Theory level it does not require a researcher to pre-select a particular model of creativity or cognition. This maintains a level of flexibility, as it allows it to be used by researchers applying different perspectives. It also allows it to be used as a platform for comparative work aimed at evaluating which of several available models best explains observed findings. This is true both at the level of the specific component mechanisms, and that of the overarching model.

The scope of the ICM is limited to explaining individual level creative appropriation. While the mechanisms that are part of the model can explain collective level cognitive operations, it is possible that there may be other mechanisms necessary to describe the operations of cognitive systems that span multiple individuals and external objects. However, the ICM may give some clues about the nature of broader distributed cognitive systems. These clues may offer insights, not only for creative appropriation, but creativity and cognition as a whole. I will speculate about this in the following sections.

## 8.5 Creativity and the Hiding Hand

It has long been suggested that human individuals can be seen as component parts of a larger organism, in much the same way that individual human cells are part of the human body (Asch, 1952). It has been suggested that the interests of these individual components and those of the host organism can differ, and be in conflict (Dawkins, 2006). For example, one explanation that has been advanced for the differing tendencies of System 1 and System 2 in the cognitive system, is that System 1 is an evolutionarily old system that optimizes for evolutionary fitness, while System 2 is an evolutionarily recent system that optimizes for individual goal-seeking (Evans, 2008; Stanovich, 2011). Is it possible that the distributed cognitive level of human cognition can itself be seen as forming something larger than the individual, something which may have interests and priorities that differ from those of its individual components?

The basis of this speculation is an observation by Hirschman (1967) which has become widely known: the principle of the Hiding Hand (Hirschman, 1967). He observed – in the domain of major infrastructure development projects in developing economies – that the individual actors involved in those projects always systematically underestimated the cost, degree of difficulty, and level of risk involved in those projects. The systematic errors were beneficial collectively in the end, because the projects themselves became valuable for the community. However they would not have been embarked on by the developers if they had accurately predicted the cost and risk that they were assuming. He expresses it like this:

*“We may be dealing here with a general principle of action. Creativity always comes as a surprise to us. Therefore we can never count on it until it has happened. In other words, we would not consciously engage upon tasks whose success clearly requires that creativity be forthcoming. Hence, the only way in which we can bring our creative resources fully into play is by misjudging the nature of the task, by presenting it to ourselves as more routine, simple, undemanding of genuine creativity than it will turn out to be” (Hirschman, 1967, p. 13).*

This tendency – to underestimate the level of creativity that endeavors will require – operates at level of societies and national projects (where Hirschman was focused), but may also explain creativity at individual level. Creative actors in hedonic or artistic contexts appear to be driven by either intrinsic compulsion or affective feedback to continue or maintain the cycle of enactment-ideation. However in the case of utilitarian creativity such as the creative appropriation of IT, what appears to drive the cycle is loss-perception: a perception that loss will result if the creative action is not engaged in. In other words, it is not done for enjoyment, and will be avoided if other options for attaining goals can be employed. That is consistent with the negative cases and the outcomes of the natural experiments. It is also consistent with systematic errors which tend to be made by individuals – even highly trained individuals – in the estimation of risk (Taleb, 2008).

Does the way in which shared prototypes at the distributed level guide judgments at the individual level serve to push individuals into risky projects that may not suit the individuals' interests, but will ultimately benefit human society by driving innovation and progress? Providing a definitive answer is beyond the scope of this thesis. The question, however, suggests interesting areas for future work.

## 8.6 Creativity and the Individual

In the Introduction, I raised the issue of those figures, both historical and contemporary, who have been part of multiple stories of creative discovery and invention, in science (Merton, 1961) and in multiple other areas (Lemley, 2011). There are some individuals who are involved in a series of creative discoveries and inventions over their lifetimes. Individuals such as da Vinci, Edison, Tesla, and, more contemporarily, Jobs, and Musk; have been involved in transformative innovations in a number of different domains. This pattern also played out in the case data, on a smaller scale. While all the cases involved some collective action, some individuals such as MP at Gamma and JS at Alpha, had been involved in a number of creative incidents, outside of the context of the specific cases investigated in this study. It is statistically improbable that this would occur unless there is some distinguishing factor which sets some creative actors apart. I asked the question “what are these people good at”? This question can now be addressed in light of the findings of this study.

It appears that multiple discovery happens because of the convergence of two major factors: one which works at the individual level, and one at the collective level. One factor derives from the fact that cognitive systems are guided in how they perform information processing operations by a shared set of prototypes at the distributed cognitive level. The shared prototypes at the DC level feed into the prototypes at the conscious (System 2) and intuitive (System 1) levels and guide the processes involved in both idea generation and evaluation. However, the prototypes are not all that is shared. There are also common mechanisms at work throughout the human cognitive system. Just as is the case in technological artifacts, shared cognitive mechanisms tend to reduce variability in outcomes (see Rogers (2003)'s definition of technology). The same mechanisms, working with common prototypes on the same problems is therefore proposed to be one underlying explanation for simultaneous multiple discoveries across several domains. This suggests that a certain type of person, faced with a certain type of problem in a certain domain, will tend to develop a similar, or perhaps identical, type of solution. This gets at one of the most fundamental questions in creativity research: what type of person is that? Or, put another way, what are they good at?

What these people are good at appears to be the process I have identified as *Simulation*. They appear to be good — at least, better than average — at creating models of the world that represent the important parts of a problem domain with sufficient accuracy to enable them to make correct judgments about evaluating and implementing creative solutions. For the serial inventors that were listed above, many of them did not work alone, and may not have been the actual initiators of some of the inventions they are

credited with. However, they did have a sense of which problems were solvable and should be allocated resources, and that also implies that they understood which ones were not solvable and should be dropped. At the individual level, this ability has been labeled “feeling of knowing”: an intuitive sense about one’s potential ability to solve a problem (Metcalf, 1986). Another factor that has been shown to be highly correlated with many types of invention is persistence and doggedness, what Duckworth, Peterson, Matthews, and Kelly (2007) have labeled “grit”. In the case of creative invention or discovery, the role of such doggedness could be modeled as the sustaining of the simulation process (DM operation) until the creative solution emerges.

At the collective level, this, famously, describes the principal role that Steve Jobs appears to have played at Apple Computer (Gladwell, 2011). There is also evidence that within Apple itself this is seen as a principal source of their ability to innovate. In 2009, Job’s successor, Tim Cook, in a conference call to investors, said “... *We believe in saying no to thousands of projects, so that we can really focus on the few that are truly important and meaningful...*” (Isaacson, 2011, p. 488). Complex inventions and difficult problems tend to require collaboration (R. K. Sawyer, 2007) as no one person may have all the different abilities (CTM competencies) necessary to completely generate creative solutions. The specific narrative of each invention, each story, is doubtless different across contexts. However, the simulation process that guides the finding of initial ideas, and the continual, iterative refinement of those ideas, seems to be at the center of the abilities that make creative individuals “creative”. The ability to maintain these processes across multiple individuals in a distributed context is also rare, and attempts to understand and formalize the processes involved have had mixed outcomes (DeSanctis et al., 2008). However, the simulation process – at both the individual and collective levels – seems to be a key to high levels of creativity. This may conflict with some popular conceptions of what leads to high levels of creativity. Often, creativity is thought to be associated with high levels of intelligence. However, this study contributes to a growing literature that suggests that creativity draws on abilities that may be uncorrelated with, and may not be indexed by, conventional tests of intelligence (Barron & Harrington, 1981; Stanovich, 2009).

However, though this may explain some of the difference in creative output between individuals, it does not explain it all. There are also matters of access to Resources (Amabile, 1983, 1988), and other opportunities which are part of every story of creativity. In those cases where creative action requires special skills, creative individuals also need the time and resources to develop those skills (Ericsson et al., 1993; Gladwell, 2008). In this case, I would suggest that there is another social mechanism which comes into play: the so-called *Matthew Effect* (Merton, 1968). Looking at the domain of scientific creativity, Merton (1968) showed that the reward structure of science ensured that scientists who were well-known got more credit for joint discoveries than their less-known collaborators. This greater credit led to greater access to resources, enabling them to be more productive, hence get more credit, and so on. This self-reinforcing cycle meant that single individuals amassed more “inventions” over time than their peers. A similar kind of reward cycle seems to occur in the social dynamics of creativity in general. Those who are

successful in a creative endeavor become known as “creative”. They then, as a result, get access to more resources, enabling them to be “more creative”. This dynamic seems to be at least as important in determining the ability to produce creative outputs as any individual difference factors — perhaps more so (Gladwell, 2008).

I propose that the mix of these two factors: simulation efficiency, and the Matthew Effect; can likely explain much of the outsize success of “highly creative” individuals. Of course, this is a speculative proposition, however it provides much scope for future work.

## 8.7 The ICM and the Self-Organizing System

This thesis set out to develop a theoretical explanation of the creative appropriation of information systems. It was established that creative appropriation would be defined as a cognitive process, carried out by the human cognitive system. As a matter of scope, this explanation was aimed at the level of abstraction that Marr (1982) defines as the computational theory level, which describes what the system does, and the logic of the strategy that it uses to do it, without attempting to specify or describe the system at the algorithmic or implementation levels. The theory therefore specifies a system of information processing mechanisms which describe information transformation processes that are a part of creative appropriation at a high level of abstraction.

The system described by these mechanisms is deeply compatible with existing knowledge in a number of domains. However, one particular area of symmetry is the pattern of transforming of direct information about the world by the Retrospective Reframing Mechanism into forms which fit preexisting cognitive models. At the individual level, this tendency has been well documented (Nafday, 2009) and one proposed explanation for it is that it may represent a mechanism for managing information in long-term memory (Ramsar et al., 2014). However, how can the same pattern of information processing be explained in group, and even societal level systems, for example: the scientific community (Schaffer, 1994)?

Fully addressing the question is outside the scope of the thesis, but I wish to propose a speculative answer.

Is it possible that this pattern of activity in science — a branch of human endeavor aimed at expanding the boundaries of knowledge — may be indicative of a kind of *chunking* at the distributed cognitive level? It has been known for some time that individual working memory is limited in capacity, being capable of holding up to seven (plus or minus two) units of information at one time (G. A. Miller, 1956). Individuals are not usually aware of this limitation because the cognitive system uses a strategy called “chunking” to efficiently organize information into structured units that, effectively, raise the capacity of the cognitive system (Bellezza & Young, 1989). There is a growing body of research on biological systems which exhibit self-organizing behaviors which supersede the intentions and interests of individual entities within those

systems (Camazine, 2003). It is now known that the individual cognitive system has a number of emergent behaviors which result from its complex architecture, and of which individuals are not consciously aware (Kahneman & Tversky, 1979; Tversky & Kahneman, 1974) – the behaviors which are explained in dual-process accounts of reasoning (Evans & Stanovich, 2013). Chunking strategies in the mind are among these emergent, unconscious behaviors. It is possible that, in the same way, distributed cognitive systems may have emergent behaviors which are a result of the underlying architecture of the system, and are thus common to many such systems? These emergent behaviors may be hidden from the conscious awareness of the individuals who form parts of the DC system – in much the way that System 1 guides individual cognition without being consciously perceptible.

An emergent information chunking behavior in a DC system would have the same functional utility that such behaviors have in an individual cognitive system. It would systematically compress large volumes of information and make them tractable. I propose that the Information Cycle Model, by making explicit the role of shared prototypes in the individual cognitive process of developing creative products, provides a possible foundation for looking at deeper questions about the distributed cognitive process. Creativity and innovation are fundamental to the development of human society at many levels, and the ways in which collective “groups”, “organizations” and “societies”, come to exhibit ‘individual’ properties such as “beliefs”, “norms” and “behaviors” is not well understood. Much simpler biological organisms than humans exhibit sophisticated self-organizing behaviors (Camazine, 2003), and such behaviors in human collectives is an interesting topic for future work.

The ICM provides a useful possible foundation for such work.

## Chapter 9. Conclusion

*“Innovation is not a “thing” that comes out of a machine fed the right ingredients. Instead, innovation is a shorthand term for a long story.”*

*(H. S. Becker, 2013, p. xiv)*

### 9.1 Introduction

This thesis began by posing a question: why has there been little research done on creativity in the IS discipline, given the centrality of creativity as an input to so many of the research domains that have received much attention in IS? Further, the extant literature on creativity in IS, in addition to being small in volume, has also been quite narrow in scope: largely reflecting a focus on developers and users creativity-enhancement systems, and largely neglecting the role of user creativity in how IT is appropriated in determining the way systems are used and their resultant effects. In this thesis, I set out to address that gap in the literature.

A review of the IS literature revealed one possible factor in the underrepresentation of creativity in the field research output: the fact that over the discipline’s history, certain models for representing how systems are used had become dominant, and that each of those models was ill-suited to facilitating intensive study of phenomena such as creativity, which have both ostensive and performative aspects. One contribution of this thesis is the proposal of a model for analyzing user-system interactions which is able to represent ideation events in a meaningful but conceptually abstract manner, and link those events to appropriation behaviors through the concept of affordances.

Another factor which may explain the paucity of creativity research in IS may be the fact that IS has lacked a suitable theoretical foundation for such research. Often, a necessary precondition for a substantial exploration of a topic is an organizing framework, such as the one that Desanctis and Gallupe (1987) provided for the Minnesota GDSS Project (DeSanctis et al., 2008, p. 554). In this thesis I have proposed a theoretical model for explaining user creativity in the appropriation of information and communication technologies. The approach used to create the model was an embedded multiple-case study of incidents in which users in ten diverse participant organizations had developed ways of appropriating IT systems that were regarded as “creative” by appropriate observers. The research question emerged from a process of iterating between theory and data, as is recommended in inductive theory-building research (Eisenhardt, 1989a, p. 546), however its final form was *“What are the cognitive mechanisms that explain end user creativity in the appropriation of Information Systems at the individual level?”* A set of cognitive mechanisms was identified, and these mechanisms were synthesized

into a model for explaining individual-level creative appropriation. The resulting explanatory model is consistent with both the case data and related literature.

In this chapter, I will discuss the contributions to knowledge made in the thesis. I will first discuss the contributions to theoretical knowledge represented by the models developed, and discuss how those contributions may create opportunities for further work on user creativity, creativity studies in general, within IS. I will then look at how applying these models to real-world problems may make contributions to practice. I will then discuss the limitations of the work, and after that will look at some of the avenues for future research opened up by the theory.

## **9.2 Contributions to Theory**

This thesis contributes to theoretical knowledge in the discipline in two major ways: proposing a new model for representing the appropriation of IT, and presenting a new model of creative appropriation as a cognitive process by users. This addresses two key gaps in the IS literature: contributing to the current conversation on how to represent user interaction with IT artifacts; and contributing to the sparse literature on creativity in the discipline, by creating a model which can serve as a foundation for future research. While the two models presented in the thesis are developed to explain creative appropriation, neither of them is inherently limited to the exploration of that specific phenomenon. The main contributions thus have the potential to serve as contributions to a number of research domains within and beyond IS. The thesis also makes a number of contributions to current debates within IS on metatheory, theory, and methodology. I will discuss each of those contributions in the following sections.

### **9.2.1 Affordance Field Theory**

The first major contribution is Affordance Field Theory (AFT). This theory expands on the work of Markus and Silver (2008) by expanding the universe of representations in their updated conceptualization of Adaptive Structuration Theory (AST) in order to fully represent the components of the interaction between a user and a system. It provides a model for analyzing such interactions, and for comparative analysis across contexts.

It also fills a theoretical gap that was left by Markus and Silver (2008) in their reconceptualization of DeSanctis and Poole (1994)'s version of Adaptive Structuration Theory. The replacement of some concepts from the work of Giddens (1984) in the original version of AST invalidated some conceptual categories which were part of that work. It should be noted that in doing so, Markus and Silver (2008) moved away from Giddens (1984) and toward Gibson (1979), and AFT is another step in that direction.

AFT is one major contribution of the thesis.

### **9.2.2 The Information Cycle Model**

The second major contribution of the thesis is the cognitive mechanisms and the integrative model that I have labeled the Information Cycle Model (ICM). This model provides a comprehensive explanation of the information-processing operations involved in end user creativity at the computational theory level (Marr, 1982). Much of what we know about the structure of the reasoning system and how it leads to behavior is based on programs of research that are centered around controlled lab experiments (Kahneman & Frederick, 2002; Tversky & Kahneman, 1974; Wason & Evans, 1975). However, controlled experiments in labs have well-documented strengths and weaknesses. Lab experiments are powerful tools for discovering and exploring the causal properties of the basic mental processes involved in cognition, but they are not optimal for discovering how those basic processes work together in real-world cognition (Dunbar, 1997). It is known, for example, that people are less likely to engage in analogical thinking under lab conditions than they are in real life (Dunbar, 2001). It has also been demonstrated that heuristic/implicit processes which can lead to bias and error in lab experiments can lead to higher quality decision making under real-life conditions (Dijksterhuis & Smith, 2005).

This supports the position of Dunbar (1997) that a full understanding of creative behavior requires field investigations in real-world environments. Such investigations will require basic conceptual models (Miles & Huberman, 1999). The ICM can provide one such model. It is compatible with, but not dependent on, a number of existing models of how the creative process works, and adds to the theoretical understanding of creativity that is being developed through current work. It also is compatible with, but not dependent on, existing models of human information processing. It therefore may provide a tool for analysis of behavior beyond the scope of creativity research. It has proven useful for analyzing data across a wide range of field situations — i.e., across a theoretical replication of case sites — and is compatible with previous findings across a range of literatures on the cognitive processes involved in innovative behavior. It is therefore useful both as an analytical tool, and as a framework for future research, as the identified mechanisms can be explored and studied.

There are obvious links between AFT and the ICM. Both are based on models of representations, and transformations of those representations. In a word, both are cognitivist models, in that they are based on abstract representations of internal mental states and cognitive structures. They both also link cognitive states with affordances. AFT does so explicitly through representation of the Affordance Field within which users make appropriation moves. The ICM does so implicitly through the activation of the Concrete Transformation Mechanism, which represents taking action in the external world, which — in an IS appropriation context — will often include making use of affordances offered by a system. It should be noted that there are some symmetries between the models which may be misleading if read too literally. For example, the operation of the Attribute Substitution Mechanism can be compared to the action of Widening the Affordance Field. Likewise, the operation of the Representation Transformation Mechanism

can compared to the action of Stretching the Affordance Field. These symmetries are intuitively attractive but should not be assumed. The models are compatible, but independent. User-systems interactions are complex, and reductionist representations of those interactions should be avoided.

### **9.2.3 Other Contributions**

The thesis makes a number of other contributions to theory.

Culnan (1987) noted that it is important to track the state of the development of IS as an academic discipline, given the dynamic state of information technology and the youth of the discipline itself (p. 342). Slightly more than two decades later, this statement remains valid. This thesis presents an analysis of one critical aspect of the discipline: the representation of the interaction between user and system. While this analysis merely represents one perspective, it does raise an interesting possibility: that IS is in the midst of a transition in terms of its fundamental assumptions. This is a process that is often difficult to perceive, given the mechanisms which tend to make scientific revolutions “invisible” (Kuhn, 1996). The thesis therefore contributes to the literature within IS that looks at the discipline itself, while contributing to the debates which may, indeed be part of a shift in paradigms in the field.

The thesis also introduces an approach to analyzing user behavior based on Dual Process Theories of cognition. While dual-process theories have been mentioned in prior IS research (Avgerou, 2013), they do not seem to have penetrated deeply into theorizing within the field (Browne & Parsons, 2012; Davern et al., 2012a, 2012b). Dual Process Theories have emerged as an explanatory framework for empirical evidence that presents a significant challenge to the assumptions that underlie a great deal of theorizing within IS. They are therefore an area of cognitive research that deserves further attention. Dual Process Theories have also been successfully introduced as a useful perspective in many other behavioral science fields (Haidt, 2001, 2007).

The thesis also presents a framework for integrating the well-established “roadmap” for inducting theory from case study data developed by Eisenhardt (1989a) with the principles for conducting critical realist (CR) case studies of Wynn and Williams (2012). Critically, the framework presented in this thesis addresses the challenge of structural analysis, the rigors of which Wynn and Williams (2012) suggest will tend to restrict critical realist case studies to single-case, or limited-context designs. It is a well-accepted truism that multiple-case designs are considered preferable in many contexts (Yin, 2009), and it is important that researchers using critical realist assumptions are able to access such designs in order to take advantage of their strengths. This thesis provides one model by which CR researchers can conduct embedded multiple-case studies. In doing so, it contributes to the still-emerging literature on CR in IS.

Finally, it is worth noting the parallel between recent developments in the literature on “use” in IS, and the move away from behaviorism in the wider behavioral sciences that lead to the development of

cognitive science. The IS discipline seems to be experiencing a similar move away from its own form of empiricist ideas, at least in the area of the representation and measurement of system use. It now seems to be moving toward more complex and rich representations of IS phenomena, as well as a greater awareness of the cognitive processes that underlie user behaviors. Given the apparent structural similarity in the underlying issues that have led to each of these moves, perhaps IS researchers can draw some inspiration from the history of cognitive science. This thesis provides one model of how this may be approached.

### 9.3 Contributions to Practice

The primary contributions of this thesis have been to theory. However, its findings also have the potential to make a contribution to practice. While Affordance Field Theory may prove useful in different settings, in this section I will focus on the possible contributions of the Information Cycle Model (ICM).

A deeper understanding of the cognitive mechanisms involved in the creative appropriation — and appropriation in general — of IT systems can be of significant use to the people who design, build, deploy and manage those systems. For example, an understanding of the Representation Construction Mechanism (RCM) processes by which users make sense of how systems are intended to be used can inform the way systems are designed (in a manner similar to that which Norman (2002)'s version of “affordances” addresses). The ICM may therefore provide a useful framework for user interaction design.

The fostering of creativity is an important goal for many who develop IT systems, and for many of those who invest in them (Kern, 2010). However, the goal of “creativity on demand” has long been, and will no doubt continue to be, an elusive one. Many definitions of what is “creative” either implicitly or explicitly include the fact that creativity is always unexpected or surprising (Boden, 1996; Hirschman, 1967). It is therefore, by definition, unlikely that creativity can be “predicted” or forced to happen under most circumstances. However, while there is no intervention that can *guarantee* a creative outcome, the ICM may suggest levers by which the likelihood of such outcomes may be manipulated. “Levers” may be more useful than “triggers” because, contrary to the ‘pro-innovation bias’ in some of the management literature, novelty may not always be desirable. Use cases of systems can be designed either trigger the DM (to encourage users to discover new ways to use the system) or to encourage SAM operation (to constrain unintended use). The former might be useful for a hedonic system (e.g., a game console); while the latter might be preferred in contexts where nonstandard use patterns are risky (e.g., the flight control system of an aircraft). In domains where accurate recording of use patterns is required, systems can be designed to log those aspects of their actuation that are most likely to be distorted by the RRM.

None of the above possibilities suggest a simple, rule-based model that can be applied blindly to all systems. For any specific system, it would likely be necessary to do empirical research to discover, for example, which RCM cues are effective in shaping which user behaviors. The ICM cannot provide blanket

answers to such questions, but can, rather, provide a useful framework for asking them, and for organizing and interpreting the answers. The ICM, as currently specified, is more of a tool for consultants than for general use. However, it may prove useful, and may, as such, prove an appropriate tool for facilitating the design, implementation and management of IT systems.

## **9.4 Limitations**

The critical realist (CR) assumption of mediated knowledge implies that human knowledge of reality is transient and imperfect. As such, in CR, findings from any single study are viewed as provisional. This is a general limitation of any single-study finding using critical realist assumptions and is a limitation of this study.

The study also has specific limitations. Both the critical realist case study framework of Wynn and Williams (2012), and the Eisenhardt (1989a) roadmap, recommend the use of multiple investigators for triangulation of assumptions and interpretations. Because of the limitations imposed by the rules of dissertation research, this project has been conducted largely by a single investigator, the author. One individual has done both the theory development and field work. While I have received feedback from supervisors during the process, the preparation, data collection, data analysis and writing have been done by me. This represents another limitation of the project.

Another limitation that must be noted is the universe to which the findings can be generalized. There have been a number of philosophical debates on the ability of non-human objects to take action and determine the course of events – on whether they can be agents (see (Giddens, 1984), (Latour, 1991)). That debate is becoming a lot less philosophical. It is now possible for interacting algorithmic systems to generate and exhibit “behavior” which cannot be predicted, controlled, or monitored by the human agents have built, programmed and deployed them (N. Johnson et al., 2013). Understanding the behaviors of these new machine ecologies is a worthwhile and important project (Lewis, 2014; Popper, 2012), but it is beyond the scope of this thesis.

There is another fundamental limitation in the design of the study, one that is perhaps best illustrated with an example:

### **9.4.1 Vignette III**

*The company had been in business since 1851, and was one of the oldest corporations in the United States. Its products had helped the Allies win the Second World War. It was an industry leader in the field of glassmaking, employed some of the most highly respected scientists in the world, and had a market capitalization of approximately 10 times the book value of its assets. Yet one of its most important products to date had come from a malfunctioning thermostat. In 1953, Donald Stookey, a*

chemist at the company, tried to heat a plate of glass to 600C in a lab furnace. He left the plate in the furnace, and while he was away, the thermal controller malfunctioned, and the temperature crept up to 900C. At that temperature the glass should have melted, but it didn't. Instead, it transformed into a new material: the world's first glass-ceramic. Its unusual properties were first revealed when Stookey made his second mistake of the day. While he was fishing the piece of glass out of the furnace it slipped from his tongs and fell to the floor. It should have shattered, but it didn't. Incredibly strong, light, and nearly impervious to huge fluctuations in temperature, the new material was dubbed "Pyroceram". It proved useful for everything from missile nose-cones to commercial cookware.

In 1959, the company set out, once again, to create a new type of glass, this time on purpose. The (then) President of the company told the Research Director, William Armistead: "Glass breaks... Why don't you fix that?" Armistead started a years-long series of experiments aimed at doing just that, investigating all known techniques for strengthening glass, and developing new ones. The company eventually developed a process that involved adding aluminum oxide to a certain glass composition before dousing it in a bath of hot potassium salt. Sodium ions in the glass were exchanged with (larger) potassium ions from the salt bath. The potassium ions were pressed together during the cooling process, creating high compressive stresses that go deep into the surface of the glass. The procedure resulted in glass that was not only extremely hard, but also remarkably flexible. However, the company lacked a ready commercial application for it, so they embarked on an expensive marketing campaign to inform industry about the properties of their new product. More than 100 magazine and newspaper articles about the material were placed by the company's public relations department. The company received thousands of inquiries about the material, and quickly identified over 70 potential uses. It could be used to make impact-resistant eyeglasses, unbreakable windows for jails, or vandal-resistant telephone booths. One of the most promising potential applications was protective windscreens for automobiles.

None of the plans worked out as the company hoped they would. Initial tests of various applications revealed problems with many of the proposed uses. Though the new glass was much more impact and stress resistant than regular glass, when it did break, it did so explosively, making it unsuitable for applications such as eyeglasses. Likewise, car manufacturers saw no reason to replace their existing laminate windshields with the more expensive high-strength product. Especially since crash tests revealed an undesirable side-effect of the much stronger windshields: although the hardened glass did reduce the risk of some types of injuries in accidents, it also increased the risk of head injuries when occupants were thrown against the windshield. The other possible applications of the new glass also did not pan out. In the end, the project was described as one of the company's "biggest and most expensive failures", and was shut down in 1971.

The company was then called Corning Glass Works, but is now known as Corning Inc. The strengthened glass product was then called Chemcor, but is now known as Gorilla Glass.

(Alice, 2013; Dyer & Gross, 2001; Flint, 1968; Gardiner, 2012)

Today, Gorilla Glass is used to make the scratch-resistant displays on the handheld devices produced by almost every major smartphone and tablet manufacturer in the world. In 2011, it accounted for approximately \$700 million in sales for Corning, and it is estimated that it is now part of more than 1 billion devices worldwide (Etherington, 2012). The story of how Chemcor went from failed product to one of the most ubiquitous tech device components in the world has been told many times, and, as would be expected from the RRM, has many conflicting versions (see, for example, the very different versions of the story in (Isaacson, 2011, pp. 470-472), and (Pogue, 2010)). However, it stands as a classic example of the point that creative innovations do not occur in a vacuum. The right idea does not come to fruition if it does not come about at the right time, given the right tools, with right team working on the right problem. Most successful products of a creative process — whether physical artifacts or novel ideas — are successful because of a synergy between the product itself and the zeitgeist of the time and circumstance in which it is generated (Flores, 2013).

S. Johnson (2010) borrowed a concept from Kauffman (2002)'s writing on evolution in biospheres to describe the way that the current state of a domain enables and constrains the range of creative products that can be created in that domain at any time: the concept of the *adjacent possible*. The basic idea of the concept is that at any moment a finite number of products can be created and succeed, depending on the availability of compatible products which can make those products useful. Products which depend on undeveloped future products for relevance cannot succeed, regardless of the subjective level of “innovativeness” or “quality” that they represent. Products like Babbage's Difference Engine that are simply “ahead of their time” do not get recognized, and so do not get the requisite level of access to resources, and so either do not get built, or if they do, do not succeed in making a real impact (Swade & Babbage, 2001). Since it is, in practice, very difficult to identify the current boundaries of the adjacent possible, this means that “creativity”, defined as the generation of products that are acknowledged as creative, is very difficult to recognize at the time, and effectively impossible to predict. This means that stories of creative invention and discovery are almost always retrospectively constructed after the fact, when the “creativity” of the product has already been recognized. It also means that real-world, in-vivo (Dunbar, 1997) creativity narratives are especially susceptible to the distortions of the RRM.

One implication of this is that a theory that describes the individual-level information-processing operations that result in creative appropriation can, by definition, tell only a part of the story of a creative incident. Modern creativity research has established that major discoveries and inventions are almost always part of a social, rather than individual, story (R. K. Sawyer, 2007). This social story is always intertwined with environmental influences, network effects, and societal value judgments. The ICM acknowledges the importance of social and environmental context, and provides a tool for future analysis

of the effects of those contextual influences through the concept of prototypes, and their role in shaping individual information-processing through the RCM and the RRM. However, the current project does not attempt to describe how the distributed cognitive system comprised of the web of individuals, prototypes and contexts lead to creative outcomes. More comprehensive descriptions of the full system are left for future research.

Today, Donald Stookey is hailed as the “inventor” of Corning Ware (the commercial name given to Pyroceram). Little thought is given to the true hero of the story: the malfunctioning thermostat. What became of the thermostat? What was its story, and its eventual fate? That detail, like many details in every story of creative innovation (Dunbar, 1997, p. 16), is lost. The participants in creation narratives have no way of knowing, at the time, which facts are mundane and which will be highly significant. There is often no way, apart from speculation, to know what effect small differences may have made to the way that a particular story would have ended, if only a detail were different. We know that common contextual, social, and individual factors influence the creative process in many cases across many domains (Amabile, 1996; Dunbar, 1997; R. K. Sawyer, 2007). However, the element of chance also plays a part in determining outcomes.

As such, theories of creativity, such as the one presented in this thesis, can only ever tell part of the story. Donald Stookey went on to have a long and productive career at Corning Glass Works. He made many multi-million dollar discoveries for the company, and eventually rose to the position of Research Director. However, he is best known outside his field as the man who invented Corning Ware (Alice, 2013). And rightly so. Another chemist may have breathed a sigh of relief at not having to clean up shards of glowing-hot glass from the floor, picked up the fragment of Pyroceram and tossed it into a disposal bin. The theory presented in this thesis can account for the perceptual and cognitive processes that led Stookey and his colleagues to realize that the lump of material from the furnace should be investigated, and, properly extended through future work, it can account for the collaborative actions they performed as they discovered novel and useful applications for it. However, it cannot account for the actions of the malfunctioning thermostat.

## **9.5 Future Work**

One test of the usefulness of a theory is the extent to which it opens up, and facilitates the addressing of, interesting questions for future research. In this section I briefly consider some areas for future research which may be facilitated by the Information Cycle Model (ICM).

Perhaps the most interesting area opened up for future investigation by the ICM is the conceptualization of the social world as an emergent self-organizing system based on interactions between shared prototypes and individual cognitive systems (Camazine, 2003). The possibility that the model of prototypes interacting with internal representations may in turn produce a model for looking at how

patterns of social behavior emerge in human groups through the ICM. Information flows through and between multiple entities often produce similar structures in the natural world, and the foundation of the ICM may provide a platform for exploring this phenomenon. Extending the model of individual cognitive operations into conceptualizations of broader distributed systems, may provide a way of looking at social and environmental influences, and how they influence individual and collective behaviors. Understanding such emergent collective-level behaviors can contribute to many domains of IS research. For example, one of the most important markets in software right now is in social media apps and platforms. Social media platforms essentially try to create self-organizing systems – groups of users who use their platform, and thus create social systems based around that platform. This is hard to do, as there is currently no consensus model of how these group-level behaviors emerge. Recently, major social media companies have invested billions of dollars in buying successful platforms rather than building their own, because no company has been able to reliably create successful user communities around particular platforms. Understanding how self-organizing, collective-level behaviors develop and propagate could provide useful clues as to how it can be done.

The rating exercise which was used to classify the cases that were analyzed in detail as “creative” produced interesting, and unexpected, differences in the criteria applied by different raters. In part, this may be a result of the divergent backgrounds of the raters. It may be interesting to probe how different individuals from different backgrounds assess the creativity of ideas, what kinds of criteria are applied, and what kinds of qualities of ideas lead them to make judgments about creativity. These types of questions are of interest to venture capital firms, research funding agencies, and almost anybody that must make decisions about resource allocation and spending priorities. The answers to those questions can also contribute basic insight on ideation processes. While it was beyond the scope of the current study to address these issues in detail, they are significant, and the ICM may provide a platform for investigating this process of assessment and judgment-making.

The ICM also provides a platform for future work on creative appropriation. The computational theory level, at which the ICM is specified, provides a part of the story, but just a part. There are many interesting questions to be asked about how and by what means the mechanisms that form part of the ICM are implemented in terms of cognitive representations and logical processes. These questions in turn lead to deeper questions about how the observed representations are physically implemented in the neural hardware of the physical cognitive system. In other words, questions about how mind emerges from brain. In addition to the deeper questions raised by how the ICM emerges from its internal structural components, there are also broader questions, alluded to in the thesis, about how emergent collective-level processes may pursue the interests of collective social entities, rather than individual actors (Hirschman, 1967). The ICM also can provide a framework for looking at the structural differences between different types of creativity, such as product vs. process creativity.

One aspect of the role of prototypes in guiding thinking is the cultural dependence of knowledge and cognitive processes. This is vividly demonstrated in the fact that “common” cognitive phenomena such as the effect of common visual illusions are, in fact, culture-specific. This is illustrated in the finding of Henrich et al. (2010) that “common” mental phenomena such as visual illusions are actually often culturally-specific. It is important to study creativity and find cultural variations in the way that cognitive processes are applied in creative incidents across cultures. The ICM can provide a platform for enumerating what specifically is it that varies across cultures, vs. what remains constant. This is another area in which there is scope for future work.

The broad scope for work at the collective level should not, however, obscure the tremendous scope for questions about individual creative cognition opened up the ICM. There are open questions in the literature about the nature of the perceptual systems that form the RCM. How the contents of cognitive representational systems are stored mentally, and can be represented themselves. The nature of the skills involved in CTM processes, and the mysteries of the processes within the Secondary Representation that lead to the development of ideas. The ICM provides a framework for IS researchers who wish to explore these questions.

However, one of the most salient areas for future work lies in the testing and verification of the Information Cycle Model itself. The falsification of mechanism-based theories under critical realist assumptions is an emerging area of research (K. D. Miller & Tsang, 2011). It is possible to contribute to this emerging research area while testing the mechanisms proposed in the ICM for existence, coherence and explanatory power.

## **9.6 Conclusion**

In this thesis I have undertaken to theoretically explain the creative appropriation of information systems by identifying and describing the cognitive mechanisms that are involved in the process. In doing so, I have drawn on a number of theoretical lenses from a number of disciplines, and engaged with a number of theories about the determinants of creativity and the nature of the creative process.

The explanation I have proposed addresses the research questions of the thesis. However, this explanation, like any explanation of creativity, is only partial. Creativity, as Hirschman (1967) notes, always comes as a surprise. What is obvious and unsurprising is not typically defined as creative. Also, in many ways, being creative often requires blind faith: creative endeavors frequently require significant investments, both in terms of personal and external resources. Yet, that investment offers little certainty in terms of return. A great many attempts at being creative fail, and far too often, our attempts to learn from both the successes and failures of attempts to be creative are frustrated by systematic distortions of our perceptions of the creative process.

Like many emergent qualities of human society, this does serve a purpose. With a clear view of the costs of failure and the unlikelihood of success, many explorers and inventors would never have embarked on great journeys that have led to discoveries and inventions that have improved lives, inspired others, and advanced the state of civilization. However, for every discoverer or inventor that has changed the course of human history, there are many others who have failed in the attempt, often at great cost.

An improved understanding of the elements involved in the creative endeavor may give future travelers a better chance of success. My hope is that the work described here may in some way contribute to such an understanding.

Gregory Baker

Human Interface Technology Lab

May, 2014

## **Appendices**

## Appendix I

### Amabile A Priori Constructs – Hierarchical Representation

#### **MOTIVATION**

MOTIVATION\Motivation to Innovate  
MOTIVATION\Motivation to Innovate\Lack of Org Impediments  
MOTIVATION\Motivation to Innovate\Organizational Encouragement  
MOTIVATION\Task Motivation  
MOTIVATION\Task Motivation\Ability to minimize ext const  
MOTIVATION\Task Motivation\Attitude toward task  
MOTIVATION\Task Motivation\Extrinsic Constraints  
MOTIVATION\Task Motivation\Initial Intrinsic Motivation  
MOTIVATION\Task Motivation\Perceived Motivation  
MOTIVATION\Task Motivation\Risk Orientation

#### **RESOURCES**

RESOURCES\Domain-Relevant Skills  
RESOURCES\Domain-Relevant Skills\Cognitive abilities  
RESOURCES\Domain-Relevant Skills\Education  
RESOURCES\Domain-Relevant Skills\Knowledge about domain  
RESOURCES\Domain-Relevant Skills\Perceptual and Motor Skills  
RESOURCES\Domain-Relevant Skills\Special Talent  
RESOURCES\Domain-Relevant Skills\Technical Skills  
RESOURCES\Resources in Task Domain  
RESOURCES\Resources in Task Domain\Sufficient Resources  
RESOURCES\Resources in Task Domain\Time Pressure  
RESOURCES\Resources in Task Domain\Work Load Pressure

#### **TECHNIQUES**

TECHNIQUES\Creativity-Relevant Skills  
TECHNIQUES\Creativity-Relevant Skills\Cognitive Style  
TECHNIQUES\Creativity-Relevant Skills\Generative Heuristics  
TECHNIQUES\Creativity-Relevant Skills\Ideation Experience  
TECHNIQUES\Creativity-Relevant Skills\Personality  
TECHNIQUES\Creativity-Relevant Skills\Training  
TECHNIQUES\Creativity-Relevant Skills\Work Style  
TECHNIQUES\Management Practices  
TECHNIQUES\Management Practices\Challenging work  
TECHNIQUES\Management Practices\Freedom

TECHNIQUES\Management Practices\Managerial Encouragement

TECHNIQUES\Management Practices\Work Group Supports

## Appendix II

### Critical Decision Method Probes

<b>Probe Type</b>	<b>Probe Content Example</b>
<i>Cues</i>	What were you seeing, hearing, smelling?
<i>Knowledge</i>	What information did you use in making this decision and how as it obtained?
<i>Analogues</i>	Were you reminded of any previous experience?
<i>Standard scenarios</i>	Does this case fit a standard of typical scenario? Does it fit a scenario were trained to deal with?
<i>Goals</i>	What were your specific goals and objectives at the time?
<i>Options</i>	What other courses of action were considered or were available?
<i>Basis of choice</i>	How was this option selected/other options rejected? What rule was being followed?
<i>Mental modeling</i>	Did you imagine the possible consequences of this action? Did you imagine that would unfold?
<i>Experience</i>	What specific training or experience was necessary or helpful in making this decision? What training, knowledge, or information might have helped?
<i>Decision making</i>	How much time pressure was involved in making this decision? How long did it take to actually make this decision?
<i>Aiding</i>	If the decision was not the best, what training, knowledge, or information could have helped?
<i>Situation assessment</i>	If you were asked to describe this situation to a relief officer at this point, how would you summarize the situation?
<i>Errors</i>	What mistakes are likely at this point? Did you acknowledge of your situation assessment or option selection were incorrect? How might a novice have behaved differently?
<i>Hypotheticals</i>	If a key feature of the situation had been different, what difference

	would it have made in your decision?
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