Human Response to Earthquake Shaking: Analysis of video footage of the 2010-2011 Canterbury earthquake sequence

A thesis submitted in partial fulfilment of the requirements for the degree of

Master of Science in Hazard and Disaster Management

at the University of Canterbury

by

Emily Susan Lambie

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

University of Canterbury
2014

Abstract

Research on human behaviour during earthquake shaking has identified three main influences of behaviour: the environment the individual is located immediately before and during the earthquake, in terms of where the individual is and who the individual is with at the time of the earthquake; individual characteristics, such as age, gender, previous earthquake experience, and the intensity and duration of earthquake shaking. However, little research to date has systematically analysed the immediate observable human responses to earthquake shaking, mostly due to data constraints and/or ethical considerations. Research on human behaviour during earthquakes has relied on simulations or post-event, reflective interviews and questionnaire studies, often performed weeks to months or even years following the event. Such studies are therefore subject to limitations such as the quality of the participant's memory or (perceived) realism of a simulation.

The aim of this research was to develop a robust coding scheme to analyse human behaviour during earthquake shaking using video footage captured during an earthquake event. This will allow systematic analysis of individuals during real earthquakes using a previously unutilized data source, thus help develop guidance on appropriate protective actions. The coding scheme was developed in a two-part process, combining a deductive and inductive approach. Previous research studies of human behavioral response during earthquake shaking provided the basis for the coding scheme. This was then iteratively refined by applying the coding scheme to a broad range of video footage of people exposed to strong shaking during the Canterbury earthquake sequence. The aim of this was to optimise coding scheme content and application across a broad range of scenarios, and to increase inter-coder reliability.

The methodology to code data will enhance objective observation of video footage to allow cross-event analysis and explore (among others): reaction time, patterns of behaviour, and social, environmental and situational influences of behaviour. This can provide guidance for building configuration and design, and evidence-based recommendations for public education about injury-preventing behavioural responses during earthquake shaking.

Acknowledgements

There are a number of people I would like to thank that have contributed and helped me to complete this research.

Firstly I would like to thank all of my supervisors, Dr. Tom Wilson, Professor David Johnston, Dr. Erik Brogt and Dr. Steve Jensen for all your time, help and support to for the past year. All the guidance and reassurances (especially at the end), that have been put into this thesis have been very much appreciated. Thank you also for including me in some of your other collaborative work.

I would like to acknowledge and thank the people who gave up time to help me get started at the beginning of this research. Thank you to Dr. Emma Hudson-Doyle for helping me understand the Transana program; to Dr. Deak Helton, for helping with ideas and concepts for the coding scheme and to Dr. Richard Parker for helping me to understand the coding process. The discussions and advice from all of you was a huge help.

Special thanks to Professor Mike Ardagh and Dr. Jo Deely for supporting this research from the beginning and working to get access to data. Your interest in this research has been very encouraging.

Thank you to the Geology Department, especially the administrative staff Pat Roberts and Janet Warburton. Thank you to John Southward who was always on hand for all my technical issues, even the really minor ones.

I would also like to thank GNS Science for the financial support, it was very much appreciated.

Special appreciation and thanks to Mum and Dad, for always being a pair of ears. All of your financial support (which adds up to quite a bit now) and endless encouragement over all this time I have spent at uni have made life so much easier. Also a big thank you to all of my sisters for always being supportive- what a team.

Lastly but definitely not least, thank you to all of my friends, especially my flatmates, for all the laughs and pep-talks. You guys are awesome.

Table of Contents

List of Figures

Chapter 5

Appendix C

List of Tables

Chapter 1-Introduction to the study

1.1. Context of Study

There is significant potential for loss of life due to large earthquakes (see Table 1.1); therefore the cause and context of earthquake related deaths and injuries need to be understood to more effectively improve risk reduction strategies.

Table 1.1: Summary of recent earthquakes that have caused significant loss of life (from USGS World deaths 2014)

Year	Country	Estimated Fatalities	Magnitude
2005	Eastern China	87,587	M_w7.9
2009	Southern Sumatra Indonesia	1,117	M_w7.5
2010	Haiti Region	31,6000	M_w7.0
2010	Southern China	22,00	M_w6.9
2011	Japan	20,896	M_w9.0

Research of human behaviour during earthquake shaking have identified a series of influencing factors which include: environment the individual is located immediately before and during the earthquake; who the individual is with at the time of the earthquake; individual characteristics such as age, gender, previous earthquake experience, and the intensity and duration of earthquake shaking (Lindell et al. 2014). These studies have also begun to develop an understanding of the actual physical responses to earthquake shaking, however, these studies have relied on simulations (Goltz and Mileti 2011; Rosoff et al. 2011) or post-event, reflective interview and questionnaires (Goltz et al. 1992; Bourque et al. 1993; Prati et al. 2012; Prati et al. 2013; Lindell et al. 2014) often performed weeks to months or even years following the earthquake event. Therefore these studies are subject to major limitations such as the quality of the participant’s memory or the (perceived) realism of a simulation.

A recent study reviewing the New Zealand Accident Compensation Corporation (ACC)[1] injury claims lodged from the 4 September 2010 ‘Darfield’ and 22 February 2011 ‘Christchurch’

[1] New Zealand Accident Compensation Corporation records information of almost every injury where medical treatment has been sought. This provided a unique dataset of the medical treatment that was sought following the ‘Darfield’ and ‘Christchurch’ event.

earthquakes found a significant amount of injuries sustained were associated with the victims' movements during earthquake shaking and immediately following (Johnston et al. 2014). Of >9,000 analysed claims 'trip/fall' were the most common cause to injury. 'Secondary movement' associated with people moving after shaking had ceased was also a significant cause of injuries. Furthermore, a comparative questionnaire investigation of individual behavioural responses to earthquakes in Christchurch, New Zealand and Hitachi, Japan found that residents' most frequent response in both cities was to stop their current activities and remain in place (Lindell et al. 2014). Thus, the actions and behaviour that individuals report in post-event reflective studies and the mechanism for injuries sustained do not provide researchers with a clear indication of what actions actually cause injury and the context in which they were caused. Therefore researchers need a methodology to analyse how people behave during the earthquake event to investigate the actions and environments that cause earthquake related injury.

1.2. Motivation for this study

In late 2010 and 2011, the Canterbury region of South Island New Zealand suffered from a series of damaging earthquakes and aftershocks (Johnston et al. 2014), referred to as the Canterbury earthquake sequence (Bannister and Gledhill 2012). The sequence included over 11,000 earthquakes, with four significant events causing severe shaking and liquefaction ground damage within Christchurch city, New Zealand's second largest population centre. The M_w 6.2 earthquake event on 22 February 2011, 'Christchurch' earthquake caused the greatest injury burden and loss of life (Richardson et al. 2013) with 182 deaths and 6,659 injuries in the first 24 hours following the event (Ardagh et al. 2012).

It is evident from the recent research of Johnston et al. (2014) and Lindell et al (2014) that behaviour and actions of individuals during and immediately following earthquake shaking are associated with injuries, it also appears from these studies that the type of behaviour individuals undertake is a contributing factor in the nature and severity of the injuries, in terms of the need to seek medical care from an earthquake injury. However these studies are unable to analyse the exact actions individuals engage in during and immediately after the earthquake shaking that lead to injuries. For instance, neither study had the available data to analyse response time, the time taken to perform an action, sequence of actions or coupled responses. Nor was the exact environment within which injuries occurred able to be considered. Due to the difficulty in obtaining credible accounts of behaviour from earthquake victims, researchers interested in the relationship between human behaviour, the environment they are in and injuries sustained, need a methodology to systematically analyse human responses to earthquake shaking using actual observations of actions during real events (see Figure 1.1).

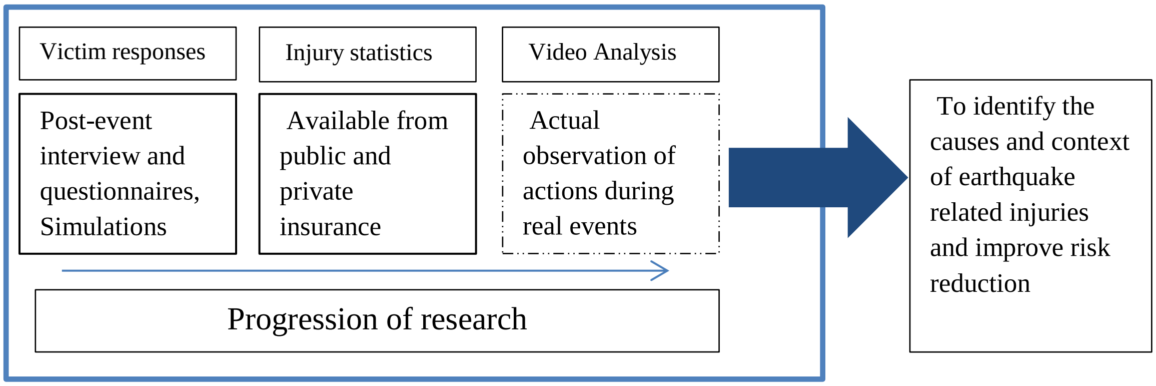


Figure 1.1: Summary of previous research and research gap

1.3. Research Aims

The aim of this research is to develop a systematic process and robust coding scheme to analyse video footage of human behaviour during strong earthquake shaking from real events. The coding scheme developed in this research will enhance objective observation of video footage and therefore, and provide researchers with an evidence base to ask questions such as:

- What actions do individuals engage in during shaking and immediately following? Are recommended public safety recommendations followed (e.g. Drop Cover and Hold)? Could protective action be performed?
- To what extent are earthquake related deaths and injuries directly related to the behaviour of the individual?
- To what extent does the location of the individual at the time of earthquake shaking influence the behavioural response?
- In what physical environments are people injured?
- Is there a shaking intensity threshold that prompts certain responses?
- What similarities or differences are there in comparing age and gender responses?

With a large data set of video data collected from a range of different events, researchers will be able to analyse how individuals respond across a range of comparable conditions. It was beyond the scope of this research to undertake a large analysis of earthquake video footage, but the thesis discusses possible applications and considerations for such future research.

This study will be an integral component to better understand human behaviour, the influences that condition people to respond in certain ways during and immediately following earthquake shaking and how these actions lead to injury. With this level of analysis researchers will be able to provide guidance for urban development in terms of, building design, configuration and regulations to reduce the non- structural hazards that people may be exposed to, as well as contribute to future revisions of the content and objectives of public education about injury-preventing behavioural responses during earthquake shaking.

1.4. Conceptual Framework

The coding scheme was iteratively developed in a two-part process, combing a deductive and inductive approach. An extensive literature review of earthquake behaviour during and immediately following earthquake shaking provided the basis for the ideas and concepts to be considered for the provisional coding scheme. The scheme was then refined, using video analysis software (Transana), from frequent, dominant and significant behaviour observed in video footage of individuals in different environments during the recent Canterbury 2010-2011 earthquake sequence. The aim of this iterative process was to optimise the coding scheme content, structure and application across a broad range of scenarios, and to increase the potential for inter-coder reliability. Figure 1.2 provides a schematic overview of the framework used to develop the coding scheme and will be referred to throughout the thesis chapters.

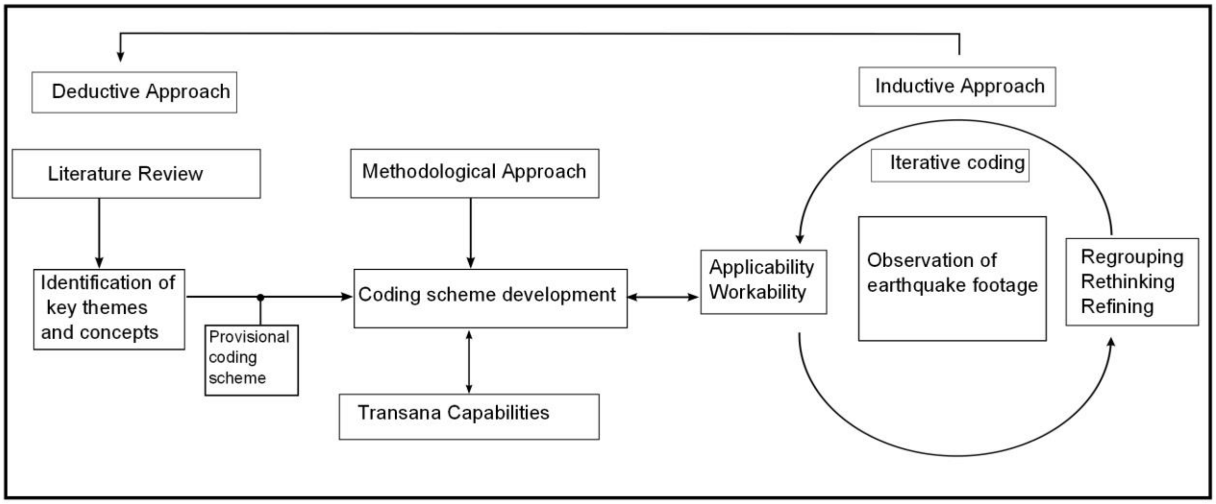


Figure 1.2: Schematic overview of the methodological framework of this research

1.5. Thesis Structure

This thesis is organised into five chapters. An overview of the purpose and content of each chapter is summarised below:

Chapter 1 Introduction to the study

- Chapter 1 provided the background in the need for research of human behaviour during earthquake shaking and introduces the aims and conceptual framework of this research.

Chapter 2 Literature Review

- Chapter 2 presents the current understanding of human behavior during earthquake shaking and immediately following to identify the key themes that need to be considered in the coding scheme.

  The methods used in previous earthquake injury research are also reviewed.

Chapter 3 Methodological framework

- Chapter 3 discusses the methodological framework and considerations that were raised in the development of the coding scheme. There are two phases:

  Phase 1: The use of video software for observation analysis.

  Phase 2: The iterative analytic stages that were worked through in the development of the coding scheme.

Chapter 4 Coding Scheme Developments

- Chapter 4 discusses how real observations of behaviour identified in a range of video footage were used to develop the coding scheme in terms of content and structure.

  The results of coded data are shown and the information that can be extrapolated is discussed.

Chapter 5 Discussion and Conclusion

- Chapter 5 discusses how a large data set of coded earthquake footage can be interrogated from multiple research perspectives.

  This chapter also discusses the major limitations that were identified in the observation of data and in the process of data collection. Recommendations for future research are presented.

Chapter 2-Literature Review

2.1. Introduction

The purpose of this review is to identify the current understanding of human behaviour and individual actions during and immediately following earthquake shaking. This is necessary to understand the content that would need to be included in the coding scheme (see Figure 2.1). Psychological and social aspects of behaviour theories were reviewed to understand general group behaviour during an emergency followed by a review of human responses to earthquake shaking and influences of behaviour. This chapter also comments on the methods and terminology used in previous earthquake behaviour studies.

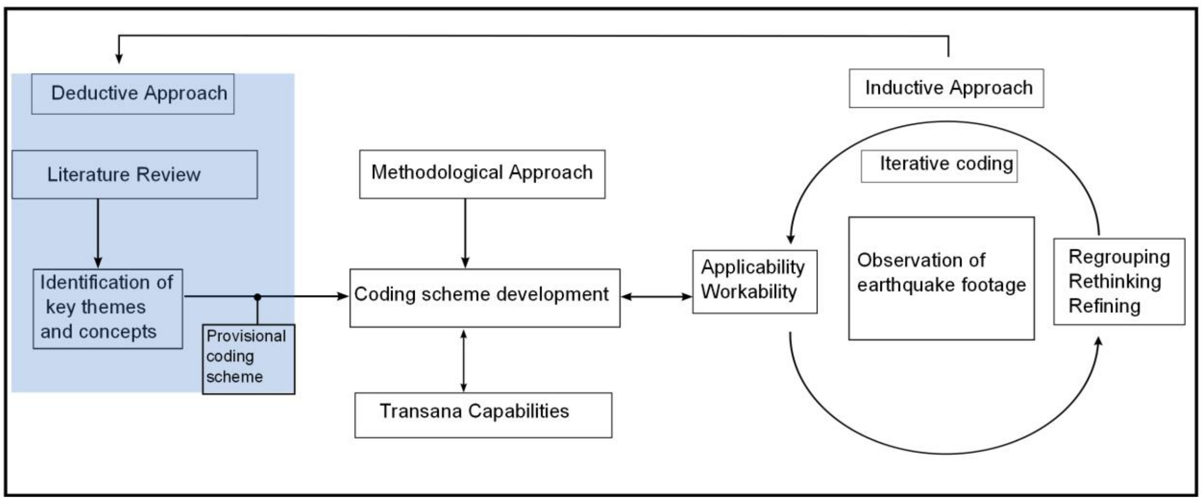


Figure 2.1: The shaded area of the diagram shows the purpose of the review of literature.

2.2. Human behaviour theories

Psychological and sociological theories of human behaviour in emergencies and disasters were reviewed to understand how people respond to the sudden onset of threat and what motivates this response.

The earliest theorization of human behaviour is panic (Solberg et al. 2008). Panic theories suggest that emotions such as fear, hysteria and anger; a breakdown of rational decision making, social interaction and non-adaptive behaviour such as flight are common responses during an emergency or disaster situation (Quarantelli 1999; Solberg et al. 2008) However, human behaviour literature has shown empirical evidence that panic and irrational behaviour during an earthquake is extremely rare (Mawson 2005; Drury et al. 2009; Cocking et al. 2009) and social interaction is more common (Goltz et al. 1992; Bourque et al. 1993; Prati et al. 2013). The absence of panic behaviour during an emergency is also supported by behaviour theories, such as The Emergent Norm Theory (Turner and Killian 1972). The Emergent Norm Theory describes the formation of new normative structures in an emergency situation to guide group decision making and behaviour (Solberg et al. 2008).The concept of social interaction is useful when considering the presence of others and how this is likely to influence immediate behaviour, for example, if an individual is at work and surrounded by other people when the earthquake shaking begins, is the individual likely to immediately provide assistance to other people? Research also shows that when the individual is alone, or perceives greater danger, affiliation behaviour and social attachment predominate. Affiliation and attachment behaviours in disasters refer to seeking the proximity of familiar persons (Prati et al. 2013) and predicts that the individual will move or remain in a place of danger to be close to familiar people and places. Such observations can be explained by the Social Attachment Model (Mawson 2005). The Social Attachment Model of human behaviour in an emergency (Figure 2.1) focuses on the maintenance of proximity to familiar persons; places, objects, group belonging and social interaction. In an earthquake context this would include behaviours such as immediately moving during shaking to reach other persons (in another room for example), rather than performing a protective action.

Table 2.1: From Mawson (2005). Showing individual and collective response to threat and danger (outcomes A-D). Precipitating conditions: perceived degree of physical danger; the location of attachment figures (friends, family), influence individual responses.

		Present	**Absent**
Perceived Degree of Physical Danger (Precipitating Conditions)	**Mild (Anxiety**)	Outcome A: Affiliation Increased attachment behaviour, that is, individuals seek proximity with familiar people and locations, as occurs in most community disasters.	Outcome B: Orderly Evacuation by Non-residents Flight-and –affiliation of low intensity. Orderly movement away from danger and toward the familiar, for example, evacuation by tourists in “mild” community disasters and “bunching” among combat troops.
	Severe (Fear, Terror)	Outcome C: Evacuation by community Residents As in Outcome A, or occasional low-to-intense flight-and-affiliation, for example, orderly evacuation in major disasters: occasional “panic” in seasoned combat units due to the appearance of new weapons.	Outcome D: Intense Flight-and-Affiliation Intense flight-and-affiliation, that is, responses commonly labeled “mass panic,” as in structural fires, and in unattached or weakly attached combat units

Logistic regression analysis used in a study of evacuation behaviour during a fire (Cornwell 2003) supports the theory of social attachment. Finding that fatality increased for individuals for whom a group member died, Cornwell concluded that the presence of familiar persons during extreme physical threat is a major component of response behaviour. However, by focusing only on threat perception and the presence of familiar persons, there is no consideration of the possibility of developing new social structures during the emergency between individuals with no prior relationship (Cocking et al. 2009). The Social Identity Theory and the Elaborated Social Identity Theory (Cocking et al. 2009) suggest that individuals in an emergency will focus of the people they are with further, predicting that people facing a common threat will show greater concern towards others, both familiar persons and strangers. Therefore the social context of an individual during the earthquake will influence behaviour.

The Emergent Norm Theory, Social Attachment Model and Elaborated Social Identity Theory suggest that behaviour during an emergency tends to be adaptive and motivated by the need to maintain social groups. Risk perception is also recognized to influence individuals' responses. Only in situations where the individual perceives greater threat, for example being alone, in an unfamiliar environment or experiencing higher shaking intensities, flight responses, such as evacuation, are likely to be observed (Mawson 2005).

2.3. Human behaviour during earthquake shaking

Earthquake behaviour research has focussed mostly on post- event responses, generally in time frames from a few hours to a few days (Goltz et al. 1992) to inform emergency management planning and policy. Far less has focused on the immediate actions of individuals during earthquake shaking. The following table presents a summary of the available research on human behaviour and includes themes of behavioural response that were used to inform the provisional coding scheme (Table 2.1). However, these studies are subject to limitations such as the memory of the individual and the realism of a simulation and therefore do not provide a complete understanding of human behaviour. Limitations of previour research are discussed in more detail in section 2.5.

Table 2. 2: Summary of human behaviour and immediate responses to earthquake shaking

Earthquake	**Study**	**Behaviour**	**Observed behaviour**
Imperial Valley 1979 M_w6.6	Arnold, Durkin, Eisner &Whitaker (1982) • Questionnaire of 118 individuals. Authors do not report how long after the event the Questionnaire was completed.	High level of adaptive behaviour. 36% took cover under a desk, 15% in a doorway. 37% froze 56% evacuated during the shaking, 5% after.	• Took cover • Evacuation; during shaking • Froze
Southern Italy1980 M_w6.8	De Bruycker et al. (1985). • Survey of 3619 people performed 18 months after the event.	55% ran outside immediately, 14.8% waited until the end of the tremor or stayed inside. 38.9% of those who stayed inside were injured than the 27.8% who ran outside.	• Evacuation; during shaking • Evacuation; after shaking • Earthquake experience
	Alexander (1990) • Personal accounts of 18 male students collected 10 days after the event.	Mostly psychological flight responses were reported such as evacuation and running. Some students had never experienced an earthquake before.	

Earthquake	**Study**	**Behaviour**	**Observed behaviour**
Off-Urakawa, Hokkaido Japan 1982, M_w7.1	Archea & Kobayashi (1982) • Interview of 41 inhabitants 5 months after the event.	31.7% froze until they determined the intensity of shaking. 14.6% stayed in the same place for the entire duration of shaking. 46.4% tried to prevent fire 39% acted to brace free-standing furniture, two subjects were injured in the process. 24.4% evacuated and 7.3% attempted to protect themselves, only two of them were successful in sheltering under furniture or doorway.	• Froze • Protect property • Evacuation • Took cover
Six Japanese earthquakes: Nemuro-hanto-oki 1973, M_w7.4; Oita-ken-chubu 1975, M_w6.4; Izu Oshia-kinkai 1978, M_w7.0; Miyagi-ken-oki 1978, M_w7.4; Urakawa-oki 1982 M_w7.1; Central Japan Sea 1983 M_w7.7	Ohta & Ohashi (1985) • Questionnaire and interview methods of six earthquakes.	Identified 3 major immediate responses: 1. Escaping from danger 2. Information seeking 3. Returning to prior activity Psychological reactions increased and behaviour performance decreased exponentially as a function of shaking intensity.	• Evacuation • Information seeking • Return to previous activity

Earthquake	**Study**	**Behaviour**	**Observed behaviour**
Whittier Narrows 1987 M_w5.9	Goltz, Russell & Bourques (1992) • Survey data of 690 residents a year following the event.	The most common immediate response was to take cover, 42.6% of who were at home and 39.5%.The second most common was to freeze, 19.3% at home and 20.2% at work. Immediate evacuation was more common at work, 17.5% compared to 9.1% at home. Other reported behaviour included: catching objects, moving away from hazards, information seeking and moving to other people 46% of those who were driving pulled over and stopped, 43% continued driving.	• Took cover • Protecting property • Information seeking • Receive/provide help • Stopped driving • Continue previous activity • Location • Evacuation immediately
Loma Prieta 1989	Bourques Goltz, & Russell (1993) • 656 participants were interviewed 8 months after the event.	72% froze or took cover, 42% were at home with children so acted to protect them and 6% of those in buildings evacuated immediately.	• Froze • Evacuation-during • Took cover

Earthquake	Study	Behaviour	Observed behaviour
Simulation, Great Shakeout M_w7.8	Rosoff, John, Burns & Maya (2011) • 23 students participated.	During the shaking 86.4% were likely to perform a drop cover and hold action and 13.6% were likely to run out of a building. 90.9% indicated they would attempt to contact family immediately following the event.	• Took cover • Evacuation • Contact family
Umbria- Marche Region 1997 M_w5.5	Prati, Catufi & Pietrantonio (2012) • 100 people were interviewed 11 years following the event.	38% of respondents immediately evacuated the building they were in 22% froze in place 12% took cover and 10% had no reaction to the earthquake shaking because of a lack of understanding of the shaking. 7% sought information, 7% tried to protect others and 4% tried to protect property.	• Evacuation- during • Froze • Inaction/ no response • Lack of understanding • Took cover • Information seeking • Provides/ Receives help • Protect property

Earthquake	Study	Behaviour	Observed behaviour
Emilia-Romagna Region 2012 $M_w5.9$	Prati, Saccinto, Pietrantoni & Perez-Testor (2013) • Online questionnaire launched the day after the event and stopped 10 days after. A total of 1,839 participants.	The most common response was to move to another room (41.9%). 35.6% of the respondents evacuated immediately, 32.9% waited in bed for the shaking to stop. Very few reported sheltering under a table or supporting wall of the house. (14.1%)	• Adaptive behaviour • Evacuation-during • Waited • Took cover
Tōhoku, Japan 2011 $M_w9.0$ Christchurch, New Zealand $M_w6.3$	Lindell et al. • Questionnaire study comparing two cities; 257 participants from Christchurch, 332 Participants from Hitachi Japan.	The most frequent response in both cities was to freeze (37.7% Christchurch; 31.6% Hitachi). Immediate evacuation was a more common response in Hitachi (27.7%) than Christchurch (10.5%) whereas people in Christchurch were more likely to take cover (17.1%; 7.2%). Other reported behaviour included: trying to protect people (Christchurch 10.1%; Hitachi 9.9%) and trying to protect property (Christchurch 5.1%; 9.9%) and continuing pre-event activity (Christchurch 2.7%; Hitachi 2.1%)	• Froze • Evacuation immediately • Took cover • Provide help • Protect property

In review of behaviour during earthquakes, common responses have been evacuation and self-protective actions, such as seeking shelter under furniture, doorway or supporting wall, and performing the recommended ‘Drop Cover Hold’ action. Protective actions were also increased when the individual was at home (Goltz et al. 1992; Bourque et al. 1993; Prati et al. 2012) this may be because people who are in a familiar place when the shaking begins have a better understanding of their surrounding environment and know where to seek shelter, therefore are likely to find shelter (Prati et al. 2012). People who reported being in an unfamiliar environment, or without family members were more likely to evacuate which could also be for a number of reasons, including; perceiving the environment as unsafe, or having no social ties (Prati et al. 2012).

Helping others and moving towards other people was identified, although, is not a frequent response (Goltz et al. 1992; Prati et al. 2012). However, when dependent children are present (Bourque et al. 1993) affiliation behaviour increases and parents will act to protect the child. Such behaviour suggests that attachment to familiar environments and people are significant influences of immediate responses to the shaking.

Ohta and Ohashi (1995) found that psychological reactions, such as feeling extremely surprised and becoming hysteric, are likely to increase with shaking intensity. The relationship between feeling fearful and flight responses was explored further by Prati et al. (2012) and Lindell et al. (2014). Both studies found those who reported feeling fearful were likely to engage in evacuation behaviour, such as escaping from home or going down the stairs immediately. Interestingly, Prati (2012) found no influence of the social context on reported fear responses. This suggests that intense fear is driven by perceived threat and the presence of familiar person does not decrease fear, as suggested in the Social Attachment Model.

Freezing is another commonly reported emotional response; remaining in place and taking no action, aside from the accounts presented by Alexander (1990) and De Bruycker et al. (1985) who reported on the Southern Italy earthquake, panic and irrational behaviour were not reported in other studies. Therefore, earthquake attributes; such as the time of the event and the individuals distance from the epicentre are also important influences of behaviour.

2.3.1. Injury

Earthquake related death and injury and the causative factor are indicators of the type and nature of behaviour the individual was engaged in during the earthquake shaking. The following table is a summary of earthquake injury literature and the type of behaviour that resulted in injury, based on a review from Petal (2011) and references therein.

Table 2. 3: Summary of death and injury research. Adapted from Petal (2011)

Event	**Causative Factor**	**Context and / or observed behaviours**
Peru, 1970 M_w 7.8	Running out into wide streets protective. Running into narrow streets hazardous (Glass et al. 1997)	• Movement type-Running
Italy, 1976 M_w 6.5	Running out crushed by falling masonry (Pomonis et al. 1992)	• Movement type-Running
S. Italy, 1980 M_w6.8	55% ran outside; 40% of those who stayed inside were injured, 28% of those who ran outside were injured (De Bruycker et al. 1985)	• Movement type-Running • Location; inside vs. outside • Evacuation
Coalinga, CA, USA, 1983 M_w 7.6	Leaving building, falls, hit by objects, 16% glass (Aroni & Durkin 1985)	• Evacuation
Armenia 1988 M_w 6.9	Staying in versus running out after first shock (Armenian et al. 1992)	• Evacuation • Movement type-running

Event	**Causative Factor**	**Context and / or observed behaviour**
Loma Prieta, CA, 1989 M_w 7.1	60% of workplace severely injured took protective action (43% of these attempting to evacuate or move to a safer place, 24% Drop cover, hold and 14% in doorways) (Goltz et al. 1992). Freeze in place or seek protection 72%. 42% of those with children went to them. Staying in place increases with age. Running outside associated with males and fear. Fear associated with seeking protection. More experienced, stay in place (Shoaf et al. 1998).	• Location; Workplace • Adaptive self-protective behaviour • Evacuation • Emotional response; fear/ froze • Movement type; running • Earthquake experience • Helping others • Falls
Northridge, CA, USA, 1994 M_w 6.7	15% jumping out window, catching falling television etc. Of those who attempted to move 10.4% were injured versus 6.1% who stayed in place (Porter et al. 2006).	• Protecting property • Movement type; jumping • Emotional response; froze inaction

Event	**Causative Factor**	**Context and / or observed behaviour**
Kocaeli, Turkey 1999 M_w 7.4	76% of injured/dead were sleeping. 20% were in bed awake. 4% were standing or sitting awake. Of the non-injured 84% were sleeping. And 16% were awake. 79% dead died during the shaking, 5% running down stairs and 8% while awaiting rescue. 52% of injured were injured during the shaking, 23% while exiting during, 15% while exiting after (Petal 2009)	• Time of day • Movement type-running • Evacuation during shaking • Evacuation after shaking
Darfield, New Zealand, 2010 Christchurch, New Zealand 2011 'Darfield' event M_w 7.1 'Christchurch' event M_w 6.2	>30% of people from both earthquakes reported a trip or fall caused injury In the Darfield event, 16.7% of injuries were unavoidable, e.g. individual was struck by falling object and 45.4% were potentially avoidable e.g. injury was caused by movement, such as taking cover. In the Christchurch event, 43.6% of injuries were unavoidable and 18.6% were potentially avoidable	• Potentially avoidable injury • Unavoidable injury • Injured during clean up

Injury research shows that movement during the earthquake and immediately following is common (Glass et al. 1977; De Bruycker et al. 1985; Goltz et al. 1992; Porter et al. 2006; Johnston et al. 2014). Whether an individual moves during an earthquake is influenced by the time of day; for example, whether people are in bed or whether people are at work; the presence of children; age; levels of fear and mobility (De Bruycker et al. 1985; Shoaf et al. 1998).

2.4. Influences on behaviour

As can be seen from Table 2.2, the influences on behaviour fall under three major categories: location; including the physical, household and social context of the individual at the time of earthquake shaking; physical earthquake hazard, including the time of the event, intensity and duration of ground motion as well as individual characteristics, such as, age gender and previous earthquake experience.

2.4.1. Location

The location of the individual is differentiated by their physical location, the location of family members, and their proximity to other people (Lindell et al. 2014). Physical location describes the type of physical setting in which the individual is located at the time of the earthquake. Goltz et al. (1992) found differences in behaviour from individuals who reported being at home to those who reported being at work, where people at home were more likely to take cover than those at work whereas individuals at work were more likely to immediately evacuate. The location of household members refers to the physical location of family members. Goltz et al. (1992) also reported higher amounts of fear associated with the presence of children when the earthquake struck. Those who were at home at the time the earthquake struck were twice as likely to take cover when children were present. The presence of others has been discussed as an influence of feeling less fearful and the individual is therefore less likely to immediately evacuate.

2.4.2. Earthquake Hazard

The time of day the earthquake occurs as well as intensity and duration of ground motion is very likely to influence the behaviour and reaction time of an individual (Petal 2011; Lindell et al. 2014). Shaking intensity is described as the severity of an earthquake at the earth surface, in terms of the physical effect to people and the built environment. If the individuals experience high shaking intensity they may not be able to control their response and become unbalanced. Shaking intensity has already been discussed as an influence of perceived threat and fear (Ohta and Ohashi 1985; Prati et al. 2012; Lindell et al. 2014). The duration of earthquake shaking is another contributing factor to individual responses. Lindell et al. (2014) reports higher perception of risk may be related to longer shaking duration. Therefore individuals who experience longer durations of shaking may be more likely to seek shelter during shaking. The time of day will influence the location of the individual, such as, whether the individual is at home, at work, or awake. For example, earthquakes that happen in the middle of the night tend to trigger delayed responses with participants reporting they wait in bed before moving (Prati et al. 2013). Individuals at work during the earthquake shaking are more likely to protect property Lindell et al. (2014).

2.4.3. Demographics

The majority of demographic research in earthquake hazards has focused on the age, gender and socio-economic trends in casualty statistics (Spence et al. 2011). It has also focused on mental health outcomes following earthquake disasters (Suhail et al. 2009; Gawith 2013). However, little research has been completed relating demographic variables, specifically age and gender, to immediate behaviour during earthquakes. The following sections discuss the research that is available for age and gender trends of behaviour.

2.4.3.1. Age

The individuals' age, in terms of situational awareness and their mobility is a major influence of their behaviour during the earthquake event. Research of the 2012 Northern Italy earthquake (Prati et al. 2013) found behaviour such as getting dressed; changing clothes, moving to another room and experiencing fear around unfamiliar people were common responses in older people; fear was also more common in younger age groups. However the time of the event was at 04:03 local time, when people are likely to have been sleeping. This may be a factor of why people experienced more fear, from being woken by ground motion or rumbling noise. Ramizen et al. (2005) reported on child injuries from the 1999 Kocaeli earthquake in Turkey. This research found increased risk of injury among ages 10-14 years and decreased risk among 15-19 years.

Reasons for vulnerability in younger age groups may be developmental, with less understanding of earthquake shaking (Alexander 1990) or seeking out their parents for protection. Older teens may be more mentally and physically capable of performing protective actions (Ramirez et al. 2005) and therefore are at lower risks compared to younger teens. These findings were similar to the results of Glass et al. (1977) who reported on earthquake injuries sustained in a Guatemalan village and found that the risk of death is lower for the youngest child. Risk of death was greatest for the penultimate child and risk decreased with increasing age. Reasons attributed to these findings were that the youngest child usually slept with the mother and therefore was more likely to be protected when the earthquake struck. It is important to note that this finding is cultural specific, as not in every culture it is common that the children sleep with parents. Shoaf et al. (1998) found that people who moved during earthquake shaking differed by age. Those who were younger were more likely to move than older people. Lindell et al. (2014) also reported older people were less likely to take cover or help others during the shaking. This may be because elderly people are less active and are unlikely to engage in behaviour associated with injury, such as running, protecting other individuals and cleaning up. Older people who live alone may also experience higher levels of fear during an earthquake and have less assistance to move and therefore are likely to remain in place during earthquake shaking (Petal 2011).

2.4.3.2. Gender

There are very few differences reported in the response behaviour between females and males (Bourque et al. 1993; Lindell et al. 2014). Previous studies have found women are less likely to evacuate during an earthquake (Prati et al. 2012; Prati et al. 2013) and more likely to seek protection, in line with Bourque (1993). Woman also report higher levels of fear, which has been attributed to the presence of children (Goltz et al. 1992; Bourque et al. 1993). Further, Lindell et al. (2014) reported earthquake preparedness to be more common in woman and therefore suggests that woman are more concerned for safety in earthquake events. Fear may also be a significant factor in the response behaviour of men; Goltz et al. (1992) found men who reported being fearful were more likely to take cover than men who were less frightened. Being male was also associated to getting dressed and going down stairs (Prati et al. 2013) and immediately evacuating (Bourque et al. 1993). This suggests that men are less likely to be fearful in an earthquake event, and therefore are less likely to seek protection rather, engage in more movement and evacuation behaviour.

2.5. Limitations of Previous Research

Earthquake behaviour research has relied on simulations (Rosoff, et al. 2011) or post-event, reflective interview and questionnaire studies (Goltz et al. 1992; Bourque et al. 1993; Prati et al. 2012; Prati et al. 2013) often performed months or years after the event (see Table 2.1). Such studies are therefore subject to limitations such as the quality of the participant's memory or realism of a simulation. Researchers argue that participants are capable of accurately recounting their behaviour and earthquake experience because of 'flashbulb memory' (Prati et al. 2012), however research shows, traumatic experiences, including earthquakes, elicit posttraumatic symptoms (Bödvarsdóttir and Elklit 2004) and dissociative symptoms (Koopman et al. 1996).

Spiegal & Cardeña (1991) describes dissociation as a defense that separates mental processes such as, emotions and memory which can lead to alterations in cognition, such as confusion and hyper vigilance; alteration in memory, such as detailed and intrusive recollections of the traumatic event and alterations in perceptual experience (Cardeña & Spiegel 1993). A study of psychological and dissociative reactions to the 1989 Loma Prieta earthquake found dissociative symptoms were frequently reported a week following the event, and although were less frequently reported four months following, many dissociative symptoms continued, including alterations to memory (Cardeña & Spiegel 1993). This suggests that the accuracy of participants' memory after a traumatic experience may be affected by dissociative symptoms and therefore affect participants' (accuracy of) responses to interviews and questionnaires.

Additionally, questionnaire studies provide incomplete detail of the behaviour of an individual during the shaking. In the study completed by Prati et al. (2013) participants were asked to select a behaviour that best described their response to the shaking by responding 'yes' or 'no' to a range of possible behaviour such as, I waited in my bed, I moved to another room, I went down the stairs etc. Other information collected from the participants included demographic characteristics, perceived risk, where they were and who they were with at the time of the event. Although this is useful in furthering our understanding of common behaviour in response to the shaking there is no knowledge of: the sequence of actions and simultaneous actions the individual was engaged in; repeated behaviour; how the individual interacted with other people present; behaviour that was performed by the participant but was not offered as an option in the questionnaire; or behaviour that was selected as not performed because the physical environment did not allow it, such as running down the stairs in a single-story house.

The studies discussed in this chapter have begun to develop an understanding of the physical responses individuals make during an earthquake shaking event, and have recognized that individual response is dependent on: their physical location, proximity to other people and location of family members; earthquake attributes and psychological characteristics of the individual. However these studies provide only limited descriptions of how these variables influence an individuals' response time, the time taken to perform an action, sequence of actions and coupled responses. Therefore, there remains large component to human behaviour in earthquake research that is relatively unexplored. Furthermore, there is no systematic method for collecting behaviour data and consequently it is difficult to obtain an accurate number of individuals who were at risk (Johnston et al. 2014) and determine if the self-reported responses in these earthquake behaviour studies can be assumed for other populations at risk of earthquake shaking (Lindell et al. 2014). Thus; observational data of actual behaviour during real earthquake events is needed to eliminate self-presentational biases (Drury et al. 2009) inherent in post-event analyses as well as a systematic and repeatable method to analyse human behaviour to different populations.

2.6. Summary

This review focused on understanding common response behaviour and influences of behaviour to inform the content of the coding scheme (see Appendix A for the provisional coding scheme). Research has identified response actions to shaking such as, evacuate, freeze, and to take cover, and possible influences of behaviour; physical location, presence of others; individual characteristics, such as age and gender; and emotions, such as, panic and fear. This review also established the difficulty of exploring immediate response actions of an individual due to: the complex interaction of contextual variables and the earthquake event and has emphasised the need to develop a process that analyses actual human behaviour rather than relying on self-reported data. The next chapter provides the conceptual framework of developing a coding scheme, and the process to apply the scheme to a broad range of video data.

Chapter 3- Methodology framework

3.1. Introduction

The purpose of this chapter is to discuss the framework and methodological considerations raised in designing and developing the coding scheme. There were two distinct methodological phases on the overall approach to constructing the final coding scheme (see Figure 3.1). This chapter is structured as follows:

1. The first part of this chapter will explain the use of video analysis software to manage, transcribe and code earthquake footage.

2. The second part of this chapter will discuss the iterative process used to develop the content and structure of the coding scheme.

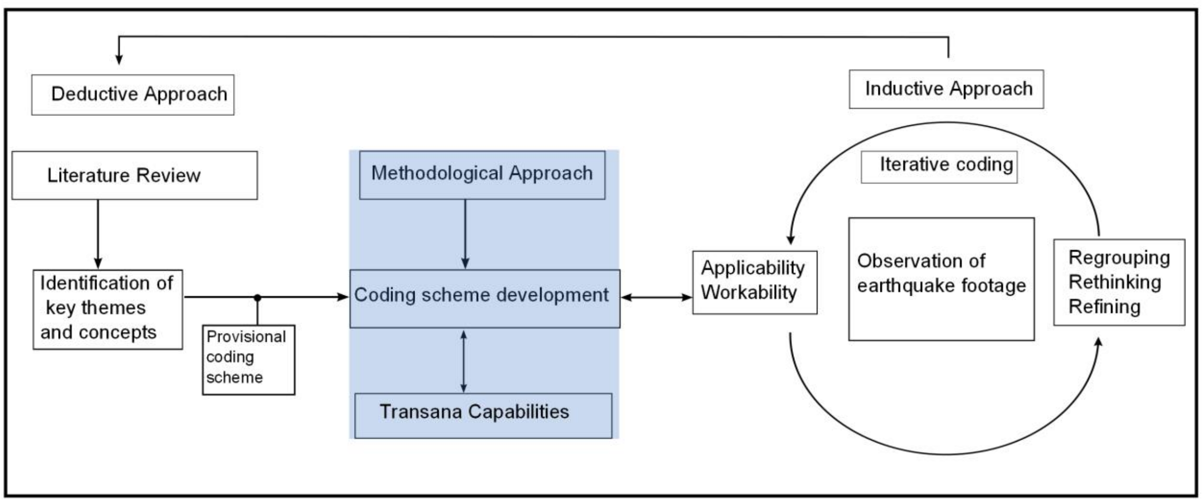


Figure 3.1: The shaded area of diagram shows the schematice overview of Chapter 3.

3.2. Addressing research gaps with observation analysis

The review of literature in Chapter 2 established that research of human behaviour during and immediately after earthquake events has begun to develop a comprehensive understanding of physical and psychological aspects of behaviour, identifying response actions, such as to take cover, or to evacuate. However the post-event reflective methods used in previous research provide limited insight to an individual's sequence of actions and the influence of contextual variables that prompt individuals to respond in certain ways.

Furthermore, there is no way to verify the accounts of earthquake behaviour that have been collected through simulations and post-event, reflective interview and questionnaire studies (Cardeña and Spiegel 1993; Koopman et al. 1996). These methods rely on the memory of the respondent, and the realism of the simulation. As a result of these inherent biases, researchers need a different methodology to systematically analyse actual human response and behaviour in earthquake events.

Observing individual’s actions during real earthquake events using video data and coding their immediate response will provide evidence of actual behavior and the sequence of actions beyond the memory of individuals. It would also allow exploration of the relationship with contextual variables allowing researchers to ask questions such as: to what extent does the location of the individual at the time of the event influence behaviour? To what extent are earthquake related deaths and injuries directly related to the behaviour of the individual? Such an analysis requires development of a robust methodology to objectively analyse individual’s actions during an earthquake and inclusion of the following information:

1. The individuals’ location at the time of the earthquake shaking in terms of the physical and social context.

2. Individual characteristics such as age and gender.

3. Earthquake attributes such as, shaking intensity and duration of shaking.

There are likely limitations in observation analysis, for example, videos having a limited field of view; being of potentially poor quality; and lack of audio data that may affect the reliability of applying coding consistently. However, it accesses a previously unutilized data source to increase the understanding of human behaviour during and immediately after earthquake shaking, and therefore can be used to inform risk reduction strategies.

3.3. Methodological approach

The methodological approach to generating the final coding scheme encompassed two distinct phases. The first phase involved designing a process to analyse earthquake footage, such as, collecting video data and selecting a program to enable the management and analysis of the data. It was recognised that to develop a robust and analytic coding scheme we needed a broad range of earthquake scenarios, for example footage with many people in the frame, footage where people were alone, people in different environments and therefore exposed to different hazards, such as an office or outside, so that the final coding scheme could be applied to a variety of video data from different earthquake events in future behaviour analysis. Therefore the selected program to analyse the video data would need to facilitate; storage of large amounts of video and audio data; allow for the development of a coding scheme; and a systematic process of observation and transcription. The following table describes the specific tasks that the program needed to facilitate.

Table 3. 1: Description of the tasks required to complete the analysis of the video data

Task	**Analytic rational**
Management of large amounts of data	To keep together related files and aspects of work that illustrate the coding process.
Analytic memoing	Documentation of key concepts, insights and ideas as they occur. This is used to record the process by which conclusions of the data are reached.
Mapping Tools	To visualize the workability and reliability of codes applied to the data.
Database sharing	Share data with team members for collaboration and consultation.

The second phase involved iteratively developing the coding scheme using the existing literature of human behaviour during earthquakes and actual observations from video footage. After identifying key areas of interest in the literature, identified in Chapter 2, as many headings as necessary were made. This formed a provisional list of themes and concepts to be considered when observing the data. Once this was completed there were several stages centered around observations of earthquake footage to ensure that the final coding scheme balanced issues of reliability and interpretability. The second phase is discussed in more detail in later sections of this chapter.

3.4. Data Collection

3.4.1. Access to data

One of the main objectives in developing the coding scheme was to use footage of individuals carrying out normal daily activities in naturalistic settings. Initially, local organisations were approached for access to footage including: the University of Canterbury, Christchurch Public Hospital, Christchurch City Council and the Crime Prevention Camera Office in the Christchurch Police Department. The response from these organisations was positive and showed an interest to share the video data; however a combination of power loss during the event and weak data management meant that video footage of the actual earthquake shaking was either not recorded by camera or had not been saved after the event.

The difficulties in gaining access to earthquake footage led to an alternative approach of using publically available footage downloaded from YouTube. This included footage of the September 2010 to December 2012 period of both indoor and outdoor footage from home, work and public environments. A total of 72 individuals from 17 different videos and different events were analysed in this project to develop a consistent and coherent coding scheme for this type of data.

3.4.2. Footage inclusion criteria

Footage used for this research, included up to 20 seconds before the onset of earthquake shaking and the moments after the shaking had stopped. This provided information of the: pre-event context, in terms of the individuals' location and activity; the individuals' response to the shaking, in terms of actions, movement type and the ability to respond based on the shaking intensity and duration; and the individuals' response once the shaking had stopped.

3.5. Data Analysis

3.5.1. Approaches to coding

Codes can be generated inductively, or deductively (Lewins and Silver 2007). Grounded theory, originally developed by Glaser and Strauss (1968), is a frequently discussed form of inductive qualitative research where categories, concepts, or constructs emerge during the process of developing theory (Strauss and Corbin 1990; Corbin and Strauss 2008). The deductive approach to coding applies predefined concepts and categories from the outset of the research, usually to test an existing theory on newly collected data (Lewins and Silver 2007).

For this coding scheme, there was no prior model of human behaviour to base a completely deductive approach therefore a combined approach was used to develop the content and categorical structure. The purpose of a combined approach was to integrate the existing literature of human behaviour to inform the foundation of the coding scheme in terms of previously identified behaviour and influences of behaviour, and to then build and develop this from emergent research findings of frequent, dominant and significant actions observed in the earthquake footage. This meant that the video data were coded iteratively to ensure that all themes in the footage had been included in the final coding scheme.

3.5.2. Available technologies

For the analysis of the video data we used Transana because it fit the criteria required and described in Table 3.1. Transana is a qualitative computer based software program designed to facilitate the transcription and coding of video and audio data and enables the data to be synchronized with transcript through the use of time codes and to create segments of data. It is increasingly used in a variety of research studying social interactions (Mavrou et al. 2007; Liston 2010; Dempster and Woods 2011; Badreddine and Buty 2011).

Unlike similar video coding software programs, coding in Transana is applied to segments of data and can be displayed across time (Afitska 2009). This allowed the unit of analysis to be the individual person and was capable of showing the temporal aspects of their response. Furthermore, Transana allows data to be exported to third-party programs, such as Microsoft Excel, for further quantitative analysis (Woods and Fassnacht 2012).

3.6. Analysis in Transana

3.6.1. Data Management

The following table and figure represents the organizational structure of Transana and how raw media files and coded data were treated in this research.

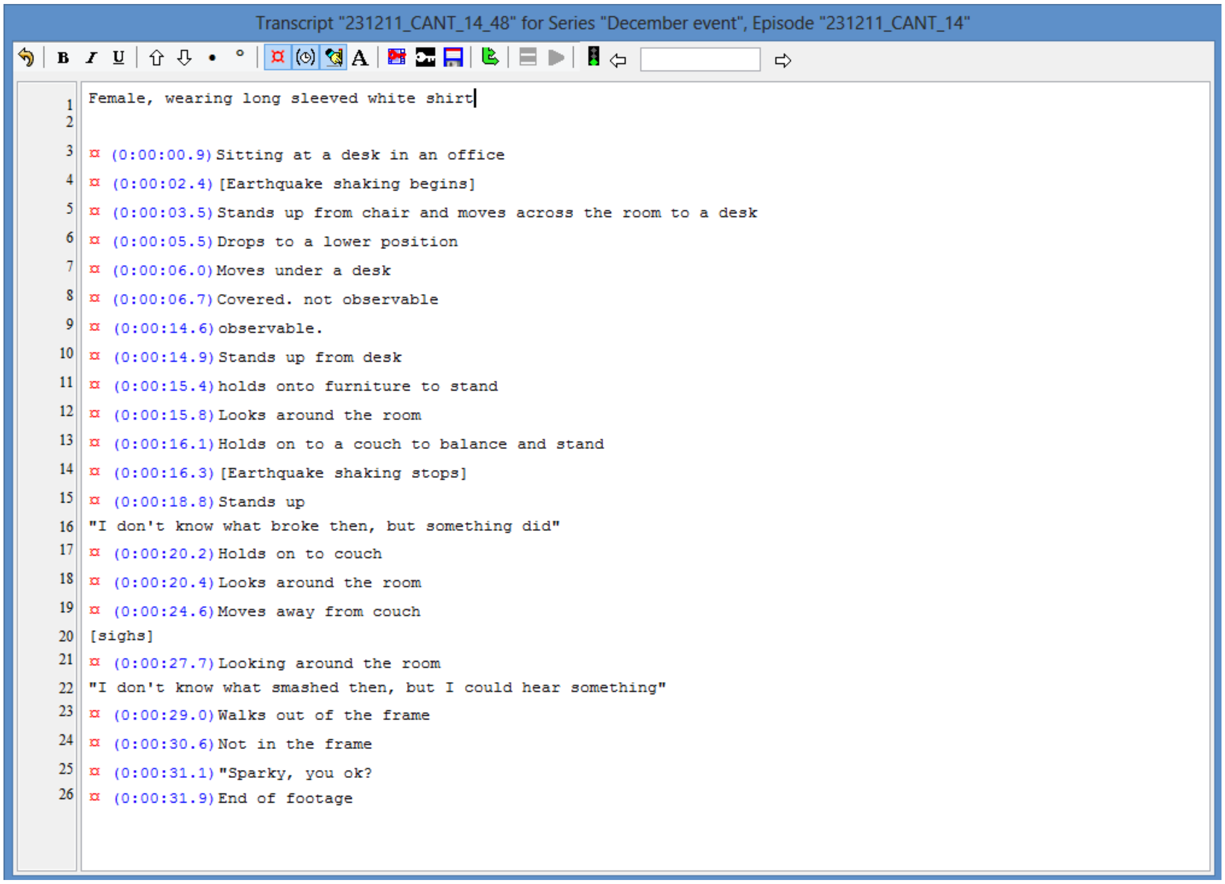
Table 3. 2: Table describing the management and analysis capabilities of Transana and how it was customised for this research

Database Organization		Properties	How it was used
Raw Media File	Series	A group of related media files (here: all video files)	The data set was comprised of footage sourced from different events and information of the location within Christchurch was not always provided, thus a series represented the month of the video and held all footage collected from that month. e.g. February
	Episode	Within each series are records of one or more collected media files. (here: an individual video)	Episodes were recorded by date and video number e.g. 220211_CANT_1 (22 February 2011, Canterbury, video number 1)
	Transcript	Each episode can contain one or more transcripts	Multiple transcripts for each episode were used to represent every individual. Transcripts were recorded by the episode and a person number e.g. 220211_CANT_1_1 (22 February 2011, Canterbury, video 1, person 1)

Database Organization		Properties	How it was used
Coded media File	Collection	A Group of conceptually related video segments made up of clips	Collections are filed to represent the transcript and therefore, the individual, the clips were created from e.g. Transcript: 220211_CANT_1_1 (raw video data) Collection: 220211_CANT_1_1 (coded video data)
	Clip	Clips are segments of the larger video file that are identified as analytically interesting	e.g. If the transcript described a person protecting contents, or seeking cover under furniture, this was highlighted and created as clip
Coding Structure	Keyword Group	Higher order category containing one or more keywords	e.g. 'Pre-event'
	Keyword	Codes are applied to clips. As many codes as necessary can be associated with a clip	e.g. 'Alone'

3.6.2. Transcription

The term transcript is used in Transana to describe any form of written record that relates to the media file (Afitska 2009). For this research, a transcript represented the timed, physical and gestural behaviour and where applicable the oral responses of each individual who entered and exited the frame during the entire length of the video. This meant that the response of every individual could be analysed and recorded separately. An example of a transcript is presented below in Figure 3.2.


Transcript "231211_CANT_14_48" for Series "December event", Episode "231211_CANT_14"

Female, wearing long sleeved white shirt

¤ (0:00:00.9) Sitting at a desk in an office
¤ (0:00:02.4) [Earthquake shaking begins]
¤ (0:00:03.5) Stands up from chair and moves across the room to a desk
¤ (0:00:05.5) Drops to a lower position
¤ (0:00:06.0) Moves under a desk
¤ (0:00:06.7) Covered. not observable
¤ (0:00:14.6) observable.
¤ (0:00:14.9) Stands up from desk
¤ (0:00:15.4) holds onto furniture to stand
¤ (0:00:15.8) Looks around the room
¤ (0:00:16.1) Holds on to a couch to balance and stand
¤ (0:00:16.3) [Earthquake shaking stops]
¤ (0:00:18.8) Stands up
"I don't know what broke then, but something did"
¤ (0:00:20.2) Holds on to couch
¤ (0:00:20.4) Looks around the room
¤ (0:00:24.6) Moves away from couch
[sighs]
¤ (0:00:27.7) Looking around the room
"I don't know what smashed then, but I could hear something"
¤ (0:00:29.0) Walks out of the frame
¤ (0:00:30.6) Not in the frame
¤ (0:00:31.1) "Sparky, you ok?
¤ (0:00:31.9) End of footage

Figure 3. 2: An example of the format and content of a transcript used to apply codes.

3.6.3. Coding

All coding in Transana was achieved by the creation of clips (see Table 3.1). Clips are described as segments of the larger video file that are identified as analytically interesting (Woods and Fassnacht 2012). For this research: audio data; actions and simultaneous actions; and contextual information of the individual, were highlighted and created as a clip. For example, if the transcript described the individual walking, this was created as a clip and coded as 'walking' if the individual stopped walking and stood under a doorframe, a second clip was created and the appropriate codes applied (see appendix C for a full description of the transcription and coding process using Transana). Because the transcripts were synchronized to the video, video playback automatically highlighted the text in the transcripts corresponding to the point in the video being analysed. This meant that the transcripts could be systematically worked through and as many clips as necessary were created from a video file, depending on the activity of the individual and how often the behaviour of an individual changed during the event. The clips were ordered numerically and coded as they were created. Figure 3.3 illustrates how a clip was created and how the information of that clip is displayed in Transana. The segment of the transcript that was highlighted to create the clip is stored with the clip properties. This also increases the reliability of applying codes because the researcher can see the text and video of what the individual is doing at that point in the frame.

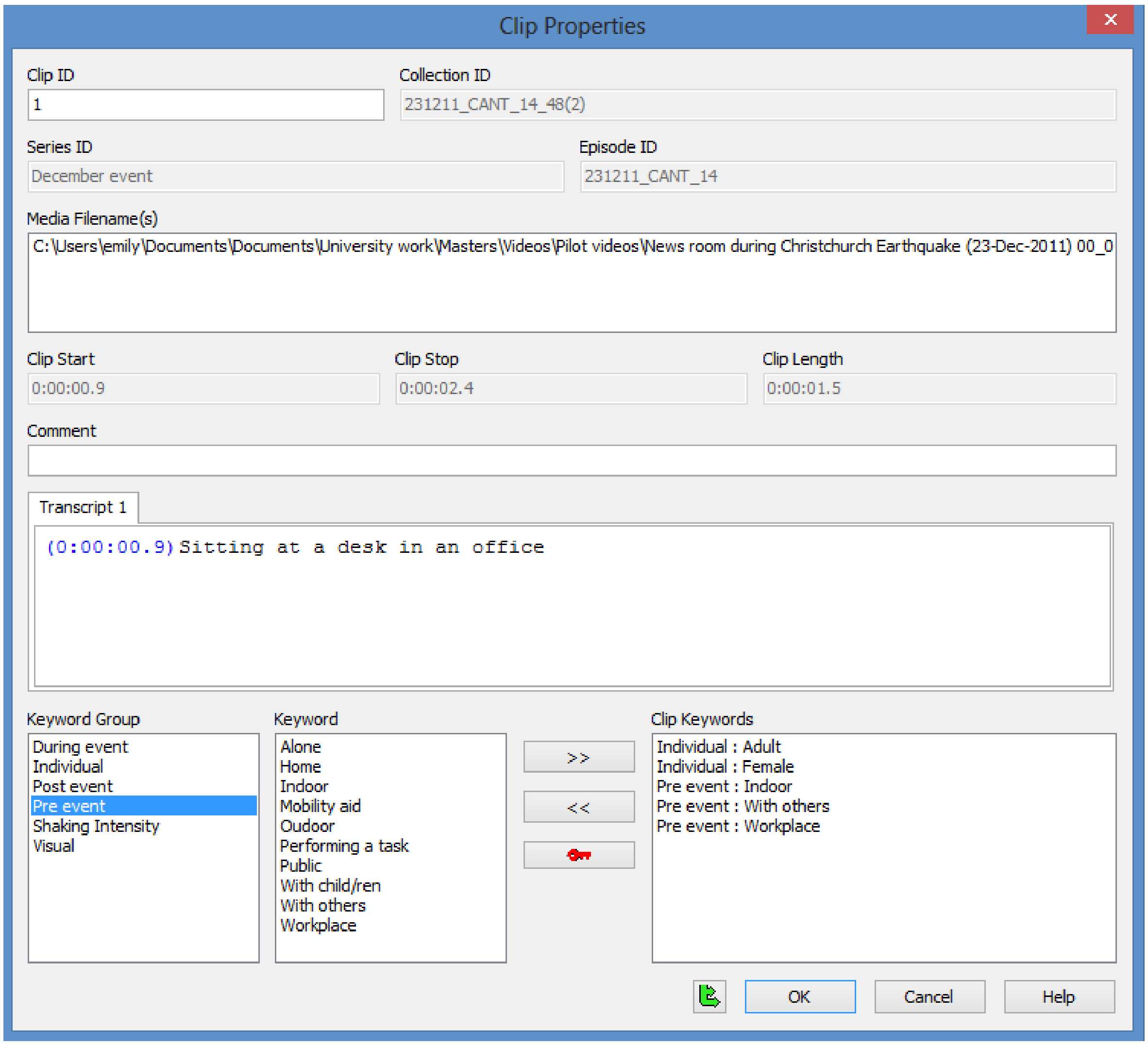


Figure 3. 3: An example of the process of applying codes to transcript data in Transana.

3.6.7. Coding Structure in Transana

Codes and Categories were developed using the Keyword management tool in Transana. This refers to the hierarchical coding structure that stores the broader category as a keyword Group which can contain one or more codes, referred to in Transana as Keywords (see Table 3.2). Figure 3.4 is an example of the creation of a keyword group and keyword.

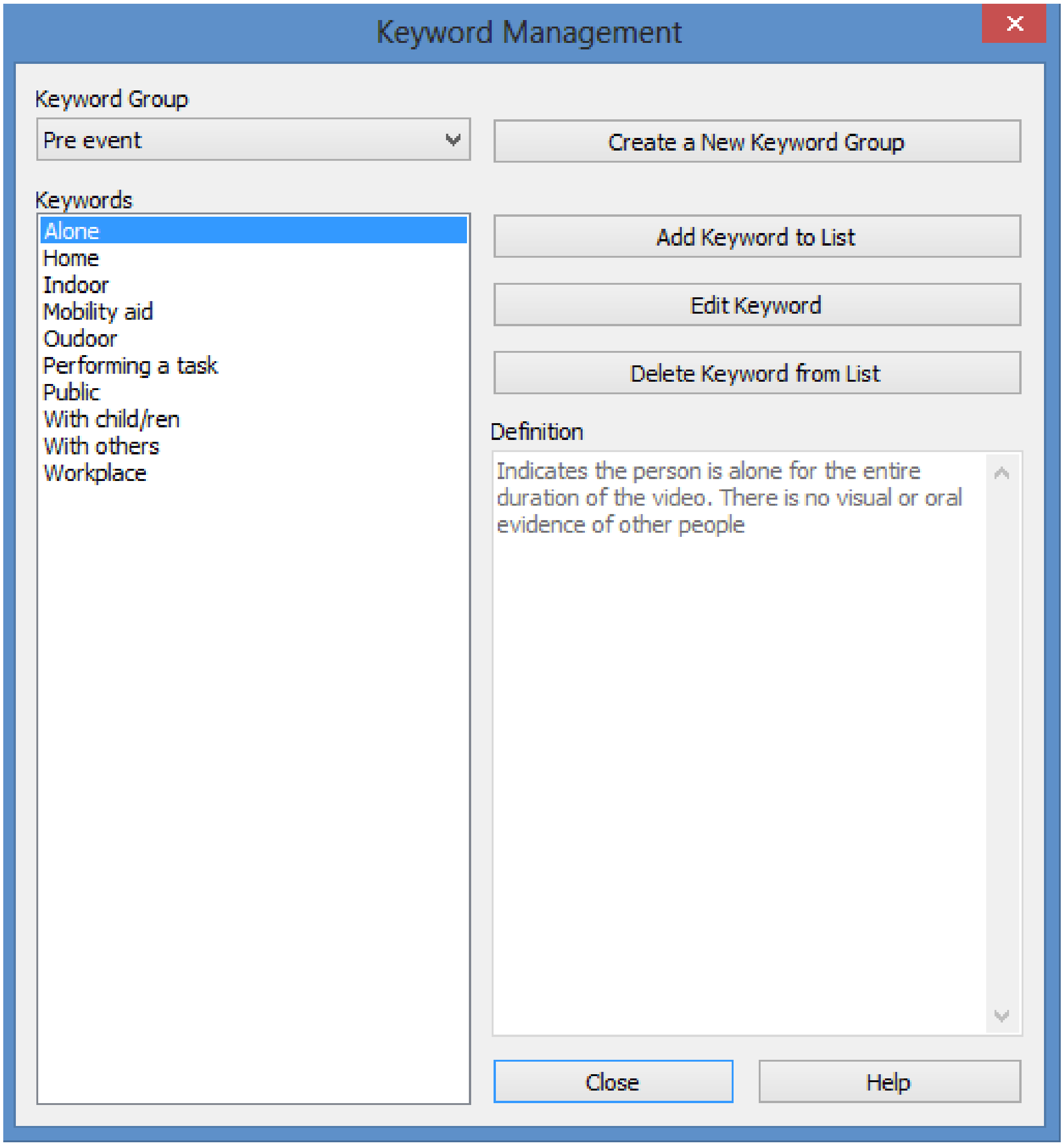


Figure 3. 4: Keyword Management tool in Transana where keyword groups and keywords are created and edited.

Each keyword within the Keyword Group can be defined. The definition of each code was used as a descriptor of the code to inform a coder when the code should be applied (see Figure 3.4). The Keyword Management tool allows Keyword Groups and Keywords to be added; deleted and edited which was useful for the rethinking, re-grouping and refinement of the coding scheme in the overall coding scheme development.

3.7. Coding scheme development

3.7.1. Criteria for the final coding scheme

The aim of the iterative approach was to increase inter-coder reliability. Reliability of a coding scheme refers to whether the analysis procedures are replicable by another researcher (Liston 2010). Issues of reliability arise when the coding scheme attempts to capture too many aspects of the data such that the scheme becomes unmanageable, similarly a coding scheme that makes too few distinctions between codes or poorly defines the codes may lead to inconsistency in the application of the codes and therefore to different results (Lewins and Silver 2007). The final coding scheme balances the issue of reliability and interpretability by creating categories and codes with clear distinctions in behaviour and contextual data. The final coding scheme was developed to meet the following criteria.

- The codes should describe only observable information of the individual and the actions of that individual to avoid any interpretation of the data, such as inferring what the individual was doing if they were not in the view of the frame.
- The coding scheme should be useable and well defined such that an untrained coder can readily interpret and apply the scheme to any earthquake event.
- The evaluation of the coding scheme reliability will be based on visual comparisons and discussion of results from separate coders.

3.7.2. Iterative coding and construct development

All developments to the coding scheme were reviewed and discussed with the project team to enhance inter-coder reliability, and to optimize the coding scheme content and organization of the categories. Because updating and refining the coding scheme was an ongoing process in this research, the development of the coding scheme is described through analytic stages (see Table 3.3). This analytic rational has been modified from the method to categorise and codify transcripts from Burnard (1991).

Table 3.3: Summary of the iterative analytic stages used in this research

Stage	Objective	Method	Developments (issues resolved)	Analytic Questions (new issues identified)
1	Identification of key themes	Literature Review	Preliminary list of themes and concepts to be considered	How can video analysis software be used to develop a coding scheme?
2	Trial of video analysis software	Preliminary coding scheme applied to simulated video. Open coding- small segments of data compared	1. Established coding process a. Data collection b. Data management (database, video and transcript files) c. Data security (identification of individuals) 2. Understanding of simultaneous and rapidly changing actions	Are all actions/behaviour considered? Are the descriptors objectively defined?

Stage	Objective	Method	Developments (issues resolved)	Analytic Questions (new issues identified)
3	Review of coding scheme content	Axial coding - codes generated by open coding are reconsidered. Coding Scheme applied to publically available earthquake footage	Actions included/removed from coding scheme, justified on the level of evidence in the video data. E.g. using phones to contact others and cleaning up damage was not an immediate response. Indicators /descriptions for codes added	How can we produce meaningful results and make sense of coded data?
4	Review of the application of codes	Randomly selected transcripts were coded twice. First using just transcripts to code and then using video and transcript. Coding consistency from the results was compared	1. Transcripts became less descriptive and are mainly used to indicate the timing of action/s 2. Keywords grouped into three broad categories: before, during, and after. Codes are applied in a temporal sense to show the sequence of actions	Are the inclusions of variables fully justified?

Stage	Objective	Method	Developments (issues resolved)	Analytic Questions (new issues identified)
5	Organization of coding scheme	Table format developed to structure categories and codes	Inclusion of codes, scenarios, reason for focus, link to literature, and justification added to coding scheme.	Is the scheme logical and clear to another coder? Are the categories distinct with clear indicators that can be consistently understood?
6	Review of coding scheme structure	Earthquake footage re-coded. Comparison of results from first coding test	1. keywords were worked through and any similar codes were collapsed 2. Keyword groups were formed if the keywords were not related to before, during, after. E.g. Visual, Shaking intensity.	Can the coding scheme be applied reliably with limited training? Are the results reproducible?
7	Inter-rater reliability check	Supervisors code transcripts, compared with the preliminary results. Discussion of inclusion/workability of variables	Keyword group/ keyword renaming and justification of exclusion of variables	Have all themes and the workability of variables as codes been considered?

Stage	Objective	Method	Developments (issues resolved)	Analytic Questions (new issues identified)
8	Iteration	Recoding of data until agreement of inclusion of variables, terms for keywords and description of keywords was met (Stages 3-7).		

3.8. Summary

This chapter has discussed the methodological considerations addressed in the design of the final coding scheme and described the combined inductive and deductive approach to optimize the coding scheme content, categorizing structure and application to earthquake footage. This chapter has discussed the use of Transana to facilitate the analytic process and management of media files the framework for the research methodology and summarised the objectives of each analytic stage that were used to generate and refine the keywords and keyword groups.

Chapter 4-Coding Scheme developments

4.1. Introduction

The previous chapter discussed the methodological framework that was used to develop the final coding scheme. The purpose of Chapter 4 is to discuss how the actual observations of earthquake footage and interpretations from the preliminary coded data were used to justify the inclusion and classification of the keywords and keyword groups to create meaningful and repeatable results (see Figure 4.1).

This chapter first provides a summary of the final coding scheme, in terms of content and structure and then discusses the development of the key themes into workable keywords.

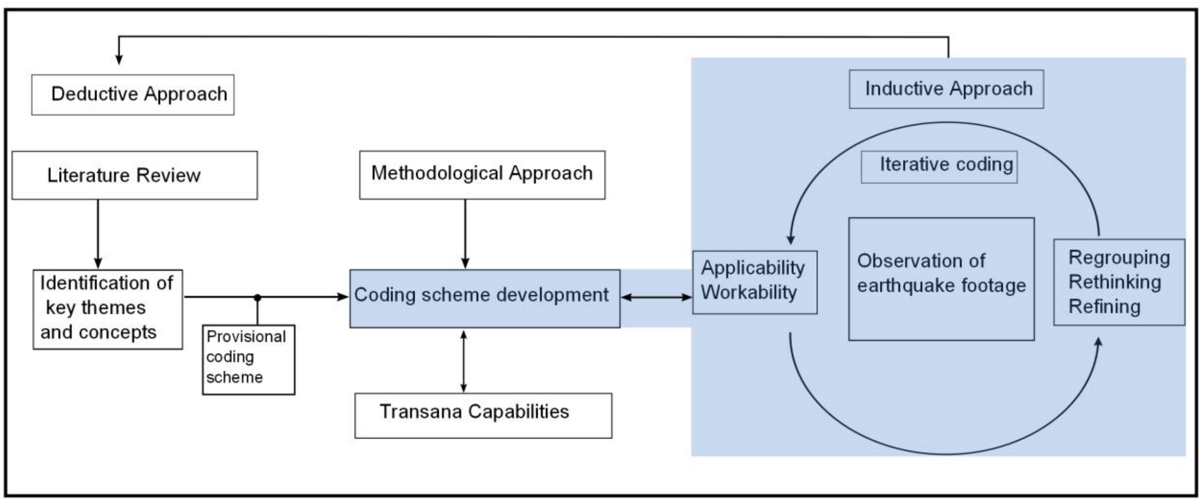


Figure 4.1: The shaded area of the diagram shows the schematic overview of Chapter 4.

4.2. Final Coding scheme

As mentioned in the previous chapter, the coding scheme was developed through several iterative analytic stages. Each stage was used to address gaps in the coding scheme, in terms of content and structure, and to direct further inquiry of the data (see Appendix B for the final coding scheme).

4.2.1. Content

The final coding scheme contains only observable information that can be extracted from the footage. It was important from the outset of this research that when describing the content of the data, in terms of physical behaviour and contextual information, the keyword group and keywords were as objective as possible to avoid any interpretation of the data, such as inferring reasons why an individual might be performing a particular action. Thus the keyword groups and keywords are labeled very basically and function as neutral statements (Corbin and Strauss 2008) and are described in detail to make clear distinctions between keywords and increase inter-coder reliability. The key themes that emerged from the analysis of earthquake footage are described in following table. These key themes have been used as a guide to group all relevant keywords into manageable keyword groups forming the hierarchical structure of the final coding scheme (see Table 4.1).

Table 4.1: Summary of the content of the final coding scheme showing how the key themes have been incorporated into the design of the keyword groups.

Keyword Group	Key themes	Analytic Rational
Individual	Contextual data (non-time dependent)	Keywords represent individual characteristics (age, gender etc.) that are applied before earthquake shaking.
Pre-event		Keywords represent location (social and physical) and activity of individual that are applied before earthquake shaking.
During event	Trigger	Keywords represent the trigger that initiated the individuals response only applied at the onset of earthquake shaking.
	Response Actions	Keywords represent the actions the individual engages in and are applied during and after the earthquake shaking.
Post-event	Injury	Keywords represent if the individual was impacted by injury and are applied during and after earthquake shaking.
	Self-protective actions	Keywords represent if the individual attempted to protect themselves and are applied during and after earthquake shaking
	Protective actions towards others	Did the individual protect others before protecting themselves

Keyword Group	Key themes	Analytic Rational
Visual	Observation of the individual	Keywords represent if the individual is observable, or do they enter/exit the frame, applied during and after the earthquake shaking.
Earthquake attributes	Shaking intensity	Keywords represent the shaking intensities the individual exposed to and are applied during the earthquake shaking

4.2.2. Structure

Using a hierarchical structure enables the contents of the scheme to be grouped according to relevant concepts and therefore enable the scheme to be easily interpreted and consistently applied (Corbin and Strauss 2008). In Transana, the coding scheme can be viewed through a keyword summary report. This report lists all keyword groups, keywords and descriptors that have been added to that Transana database (Figure 4.2).

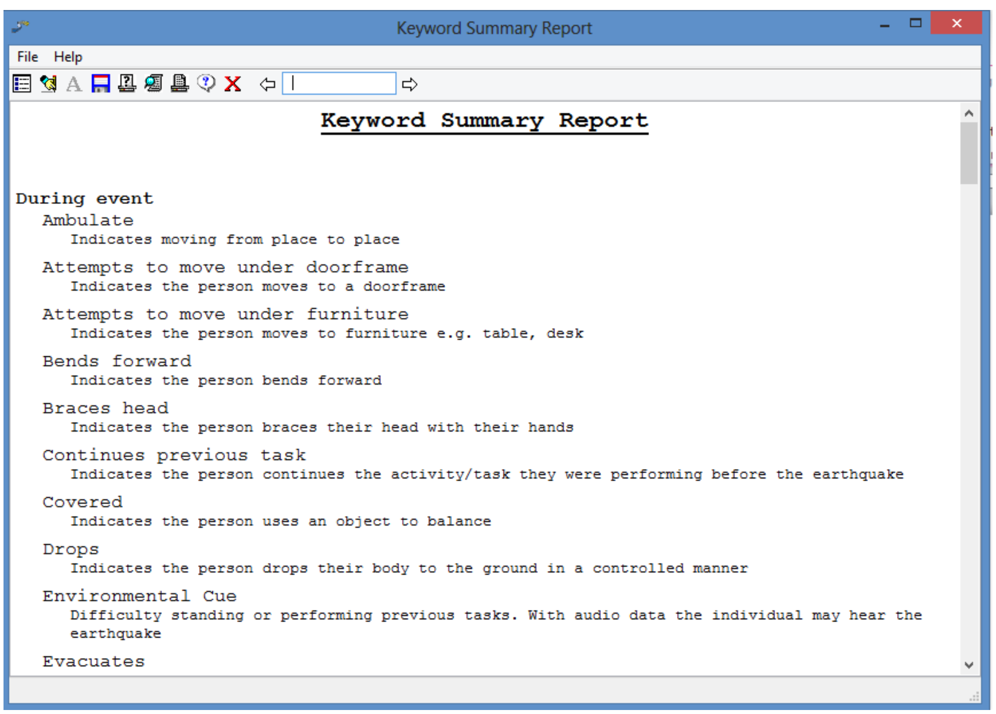


Figure 4.2: Screenshot of a keyword summary report produced in Transana.

Although the summary report was useful to confirm that keyword groups and keywords had been added to that database, it fails to communicate to a coder the analytic reasoning as to why a particular keyword has been included or what key theme the keywords represent.

It was decided that in order to increase inter-coder reliability, further description and detail of the keyword groups and keywords needed to be provided to justify inclusion and classification. Thus, the coding scheme was also worked with as a separate document. This allowed flexibility in the way the keywords were ordered, and allowed additional information to be included, such as scenarios and examples of when it is appropriate to apply a keyword. With additional description the coding process is systematic and robust, as the coding scheme has detailed information to guide the coder.

The final coding scheme is presented in a table format to include:

1. The key themes
2. The keyword group (Category)
3. The keywords (Code)
4. A low resolution keyword option for instances where it may be difficult to apply a keyword, for example coding for impact of injury.
5. Descriptions of the keywords and scenarios of when a particular keyword should be applied, and to resolve any discrepancies in the meaning of a keyword.
6. References, to provide a clear link to the literature for further information and to highlight what concepts were developed from previous research.
7. Relevance statements explaining to a coder the analytic reason for the inclusion of a keyword group or keyword.

4.3. Development process

By observing, transcribing and coding the data iteratively, all themes could be considered and worked into the final coding scheme. In some instances, keyword groups were either; collapsed into broader categories, where the distinction was not necessary because they represented similar themes; removed from further analysis because of the high level of uncertainty in the interpretation of the keyword and therefore the application to the data; or refined to make clear distinctions between keywords. This frequently resulted in the reviewing, regrouping and rethinking of the keyword groups and keywords.

Analytic memos were used continuously at every stage of the development process, recording all discussion-based progress. Discussion was focused on:

1. Does the coding scheme capture the behaviour data we want?
2. Is the right behaviour data being collected?
3. Is there any duplication with other keywords?
4. Are the keywords objectively defined?
5. Should keywords represent the absence of data? For example, yes there is injury, no there is no injury

This process was continued until all themes identified in the footage were addressed and agreement of the classification of keyword groups and keywords was met.

4.4. Selection of Keyword groups

The keyword groups (see Table 4.1) were developed to represent the temporal component of the earthquake as pre-event, during event and post-event. Therefore, when the keyword groups are applied to the data, the response of the individual is categorised according to the progression of the earthquake sequence. This is important to show when particular actions are most likely to occur, for example, evacuation, self-protective actions or when an individual is most likely to be injured. Individual, visual and shaking intensity categories were developed as separate keyword groups because they are not directly related to the individuals response.

4.5. Selection of keywords

The following sections justify the inclusion and classification of the keywords based on the actual observations of earthquake footage.

4.5.1. Contextual Data

Contextual data represents non-time dependent information of the individual such as age and gender, and the pre-event context, such as the physical and social location of the individual and whether they are alone or with another person.

4.5.1.1. Age and Gender

Previous research has focused on the age and gender of an individual to assess the similarities or differences in response to earthquake shaking. To include the gender of an individual as a keyword, female, male and unidentifiable keywords can be applied.

Developing keywords to describe the age of an individual was more challenging. Previous studies report age increments of 10-20 years however; numerical age is not observable and therefore not workable as a keyword. Therefore, age groups were developed to describe the physical and educational development of the individual as: infant; pre-school age; primary school age; secondary school age; adult and elderly.

Because the boundaries between the age descriptors cannot be defined exactly, for example the difference between a 10 year old and an 11 year old child may be difficult for a coder to determine, there are three lower resolution keywords: Age 1, estimated less than 5 years of age; Age 2, estimated 6 to 18 years of age and Age 3, estimated 19 years and older. The higher resolution keywords can be applied if there is an observable feature that makes the age clear, for example, the height and build of the individual (see comparison between Figure 4.3; A and B) Where the age of an individual cannot be determined, the unidentifiable keyword can also be applied.

Figure 4.3 Screen shot showing the difference in age groups of (A) primary school age and (B) secondary school age child (absfam10 2011).

4.5.1.2. Previous health status

Disability was also considered to be an influence of behaviour as it can potentially affect the individual's physical ability to respond to the earthquake shaking. Kobes et al. (2010) described an individual's mobility using four levels: high; temporarily reduced; permanently reduced and dependent mobility. However, determining the nature of a disability and the impairment of the individual, in terms of a temporary disability, or permanent disability, from observations in the footage was considered to be too uncertain. The keyword was developed to ‘mobility aid’ indicating that the individual has any mobility aid, such as a walking frame, wheelchair, guide dog etc. (See figure 4.4).

Figure 4.4: Screen shot of elderly man (left), with a walking stick, as an example of when the keyword mobility aid should be applied (WakeUpWorld 2011).

4.5.1.3. Relationships

Relationships were also highlighted in the literature review (see Chapter 2) as a major influence of affiliation behaviour, where individuals seek the proximity of familiar people, such as moving towards another person or helping another person during the event. However when observing the footage there was too much interpretation to determine if individuals in the frame are responsible for, or have established relationships with each other, for example; a parent, husband, caregiver, teacher, or employer to assess how the presence of others influence behaviour, the keywords focus on coding if the person is alone, with another person/people, or if there is a child (secondary school age and younger) present in the frame. These keywords avoid interpreting the data but can be used to analyse how the presence of others, especially children influences the response of an individual (see Figure 4.5).

Figure 4.5: Screen shot showing a woman protecting a child (Wendy84457 2011).

4.5.1.4. Location

Location was discussed in the literature review (see Chapter 2) as an influence of behaviour, concluding that in different environments individuals respond differently. For example, individuals at home are likely to seek cover, whereas individuals at work are more likely to evacuate. Thus, location is coded for as either inside, outside and in the context of home, workplace or a public place. Further breakdown of the location in terms of building construction type, height, floor level, whether the individual was located near an interior or exterior wall was also considered however due to the still camera angle and the exact location of the camera not known, this was considered too impractical to code for with certainty.

4.5.1.5. Previous activity

Initially the focus of the coding scheme was the observed behaviour of the individual during the earthquake shaking. However, to understand the individual's change in behaviour as the earthquake shaking progressed, it was necessary to include the activity the individual was engaged in before the earthquake shaking began to indicate whether the individual responded to the event, or continued performing their previous activity. The keywords were developed to indicate if the individual was active, referring to any activity that the individual was engaged in, or sleeping.

4.5.2. Trigger

It was also important to code how the individual recognised and processed the earthquake event. Earthquake trigger variables are included from the Protective Action Decision Model (Lindell and Perry 2012). According to the PADM, the process of initial human response to a threat begins with the perception of threat, in this instance; ground movement rumbling noise. The perception is initiated by environmental cues, social cues or by a communicated warning. There is no technological capability to provide warnings for the onset of local earthquake shaking to notify people of immenent shaking, so this has not been included as a possibility for threat perception. Environmental cues and social cues have been developed to indicate the trigger to the event, that initiated a response. Environmental cues are sights and sounds which signal the onset of earthquake shaking. Observable indicators of an environmental cue include evidence of difficulty in performing a task, such as loss of balance while standing. If there is audio data synchronized with the footage the person may hear the earthquake. In this instance an indicator may be the person looking around.

A social cue is an individuals' observed change in other people's behaviours (Lindell and Perry 2012). This cue can only be considerd if there are other people present in frame. An example of a social cue to the earthquake may be that a person only takes an action, after another person in the frame has responded. For example, Figure 4.6 (A) shows a woman responding to the earthquake shaking (environmental), while others remain seated. The other individuals respond to the earthquake shaking (see Figure 4.6 B), after observing the change in her behaviour (social). This is important to assess whether individuals response to the event is due to the actions taken by other individuals, or whether they acted instinctively and performed a protective action immediately.

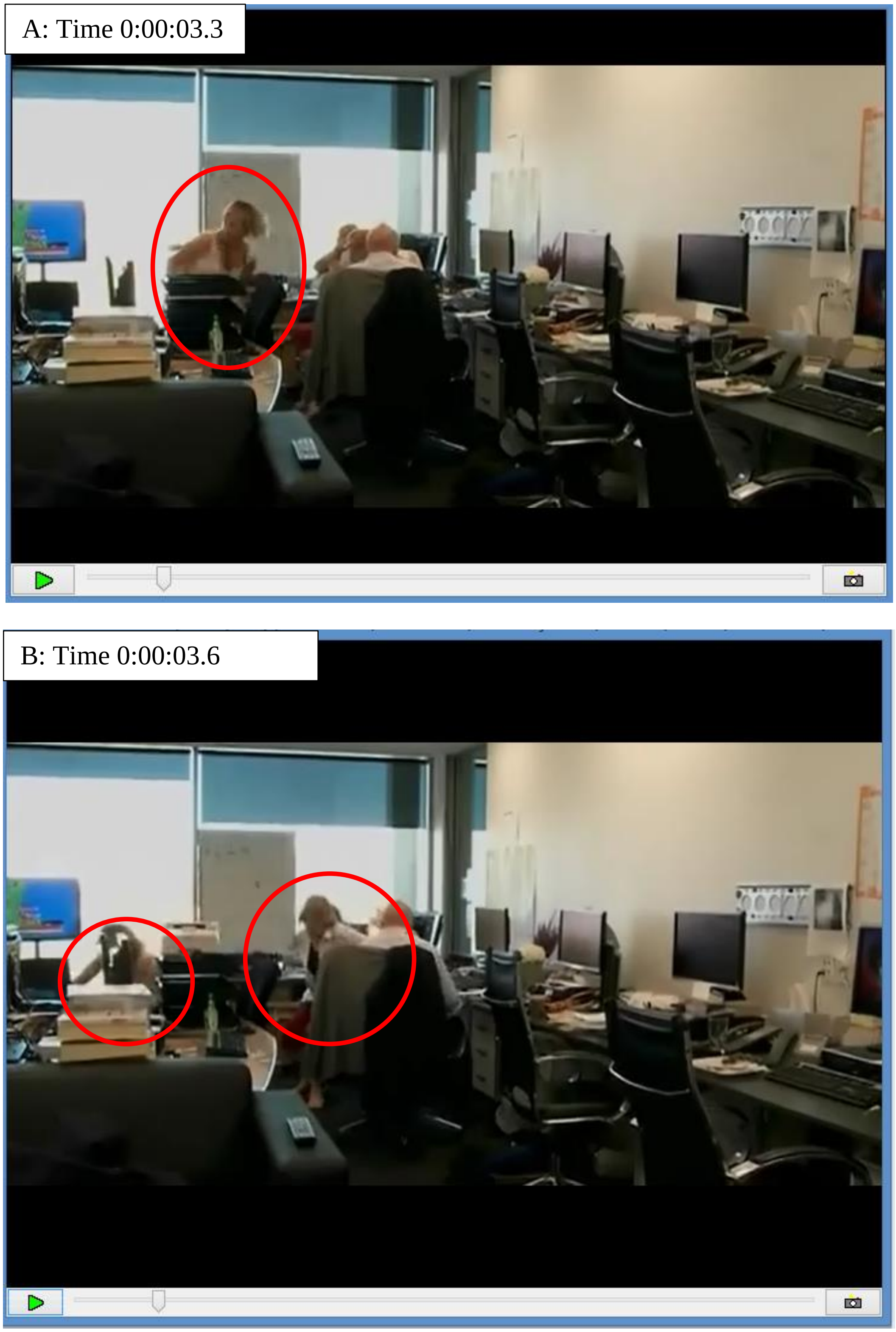


Figure 4.6: Screen shot showing the difference in environmental trigger and social trigger (A) Woman (left) responding while other individuals in the frame have not yet responded; (B) Other individuals (right) taking action, only after observing the change in behaviour of the woman. It is important to recognise that the woman (left) who responded first is almost covered when the other individuals (right) take action (The Telegraph 2011).

4.5.3. Response Actions

The response action keywords were developed to represent the movement type of the individual, such as running, walking or ambulating; whether the individual sits, stands, evacuates, attempts to protect contents, uses a phone, or continues performing their previous activity.

Previous research has reported that people will try to protect contents from falling or overturning. The descriptions that have been previously used to describe this action were either unclear, 'Against Overturning' (Koyama et al. 2011) or too specific, 'Caught objects'(Goltz et al. 1992) The keyword, protects contents, was developed to describe any instance where the person moves to any object, e.g. television or chair and describes any form of protection e.g. holding, catching etc.

It was also important to develop keywords to represent that the individual could not respond to the event because of factors beyond their control, such as strong ground motion. The keywords; uncontrolled response, falls, hit and immobilised are applied to indicate if an individual was slowed or prevented from performing any (protective) action.

4.5.4. Injury

It was important to include whether the individual sustained injuries during the event to assess the extent that behaviour, or individual characteristics can be related to the type or nature of injuries.

Initially injury severity was considered as potential keywords. Injury severity can be differentiated into four levels: minor (the individual requires first aid), medical care required (the individual is an outpatient), serious (hospitalization of the individual is required) and fatal (Petal 2011). However it was discussed that the severity of an injury cannot be differentiated accurately because the prior health status is not known. Therefore relatedness to the earthquake or the causative factor of the injury is uncertain as well as the medical care sought by the individual after the earthquake event. Furthermore to classify 'minor' injuries sustained is misleading as it may have prevented the individual from greater injury or death (Petal 2011). For example if the individual was moving to a doorframe and tripped, sustaining a minor injury may be acceptable if the individual had remained in place and had been struck by a falling object causing greater injury.

Injury is thus coded for depending on the level of impact the injury caused to the individuals' ability to respond to the shaking. It can then be assessed if it was the behaviour of the individual that caused the injury, such as running and tripping, or whether the injury sustained was beyond the control of the individual, for example if the individual is unbalanced because of strong ground motion. There are four high-resolution keywords that a coder can apply if there is evidence of injury in the footage of each scenario. They are:

1. Injury 0: injury status unclear, for example the individual is struck by a falling object and they are no longer in view of the camera, therefore the impact is unclear.
2. Injury 1: No evidence of impairment, for example the individual is struck by a falling object and continues walking therefore the impact is unclear.
3. Injury 2: Evidence of impairment, for example the individual is struck by a falling object and there is visual and/or auditory evidence of injury
4. Injury 3: Incapacitated, for example the individual is struck by a falling object and there is no subsequent movement.

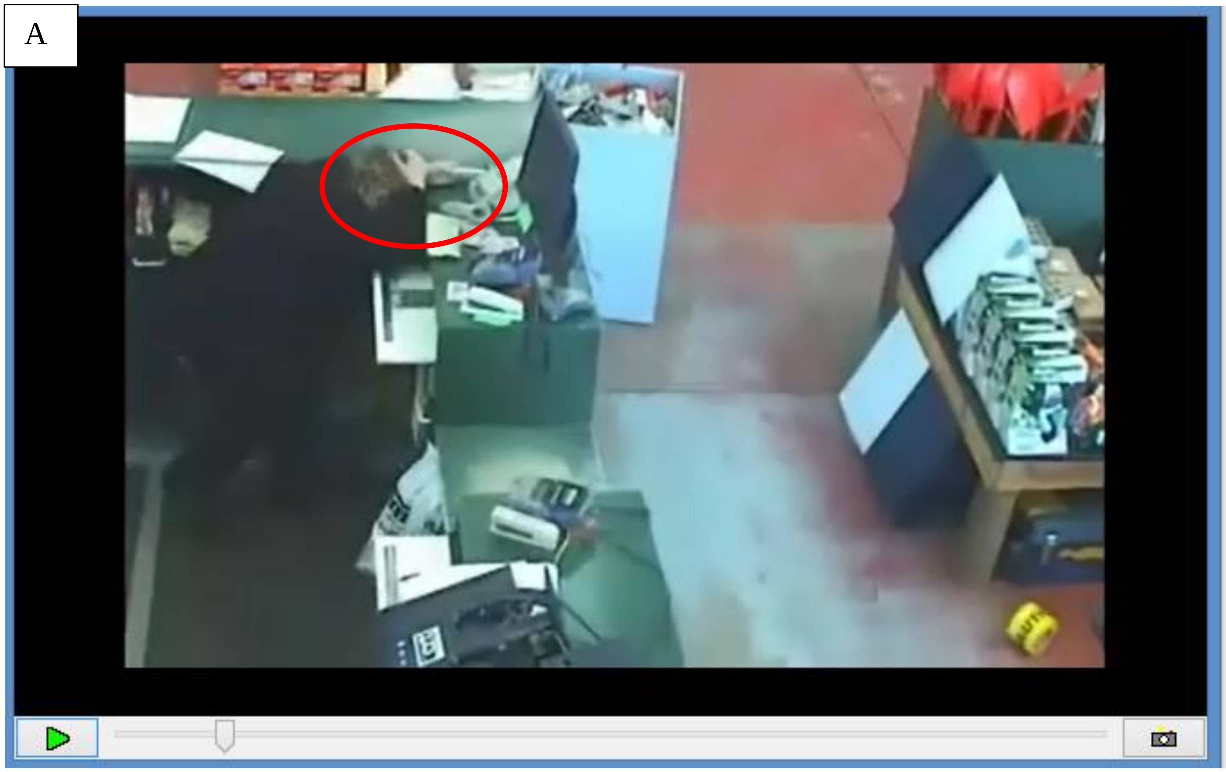
If the impact of the injury to the individual is unclear to a coder then the low-resolution injury keyword can be applied. It is important to note that the low resolution and high resolution injury Keyword is also only applied if there is evidence of injury. This is to avoid coding for non-injury needlessly and clutter the coded data.

4.5.5. Self-protective actions

The self-protective category was a key theme established in the literature review. The descriptions of self-protective behaviour in previous literature included: took cover (Goltz et al. 1992; Lindell et al. 2013), seeking shelter (Prati et al. 2012), protecting oneself (Archea and Kobayashi 1984) or sought protection (Bourque et al. 1993). However there is no specific information as to what the individual did for protection.

The keywords have been broken down to: bends forward; braces head; drops; attempts to move under table; attempts to move under doorframe; covered; and holds. This is because an individual may attempt some but not all actions or may not be successful in completing an action. For example, the individual may successfully cover themselves under the table but does not wait for the earthquake shaking to stop before they move again, or the individual may not be near any furniture to cover themselves, so may cover their head with their hands, or holds furniture for stability (see Figure 4.7). The actions have been developed as separate keywords to indicate if the individual does one, or all of them.

A



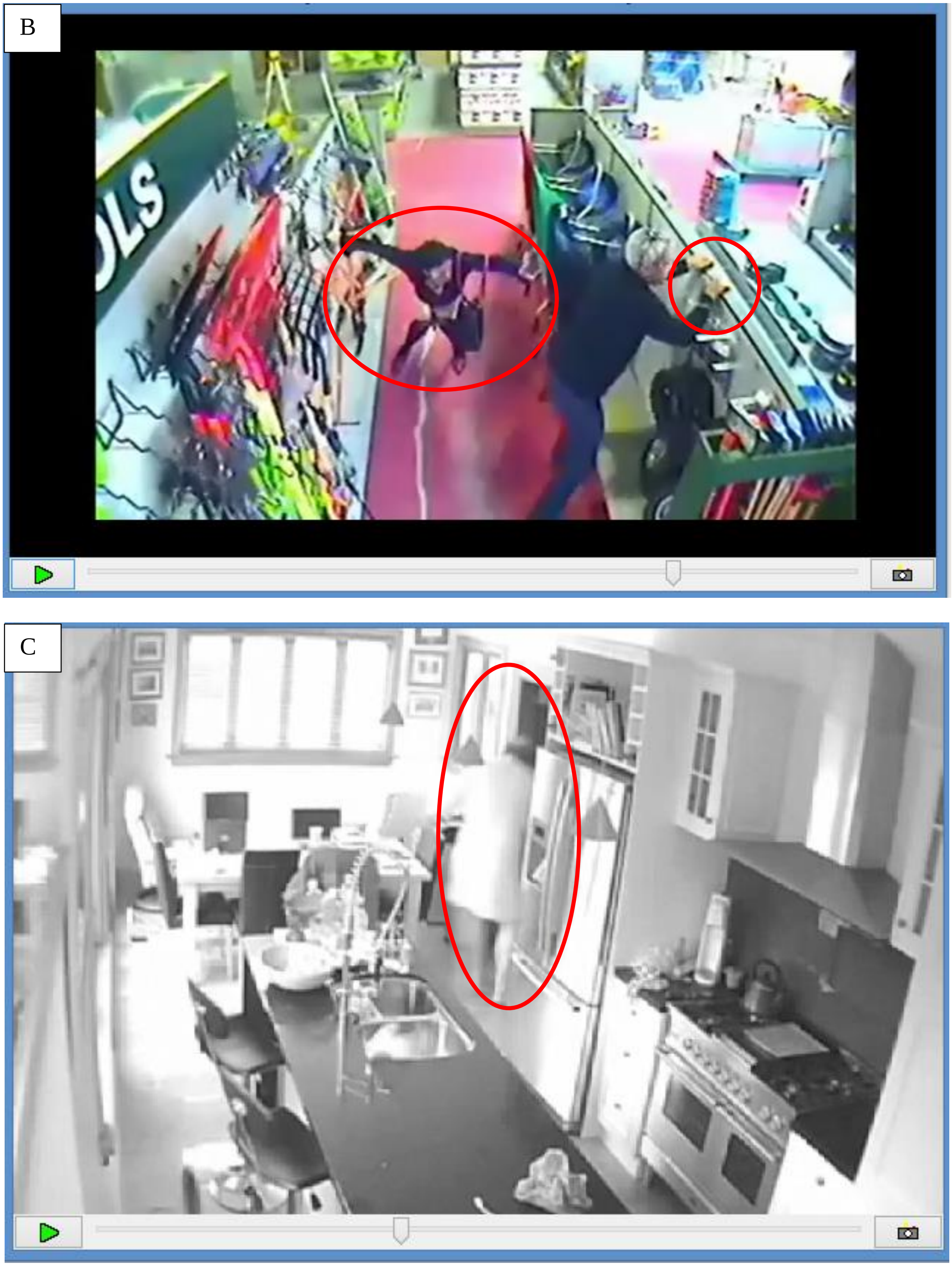


Figure 4.7: Screen shot showing protective actions performed during earthquake shaking (A) woman braces head; (B) female bends forward and male holds shelf (Dyres Road ITM); (C) individual moves under doorframe AndrewHuntley 2011).

4.5.6. Protection towards others

Protective action toward other individuals was another key theme established in the literature review, indicating whether the individuals act to protect other individuals, or provide help to another individual. Provides assistance and receives assistance were developed to code for instances where the individual either physically helps another person, or is physically helped by another person for example, physically covering another individual (see Figure 4.5), or being helped to walk. The keywords were added to after observations of the earthquake footage showed that protection to other people could also be communicated, for example, telling someone to stand under the doorframe or to evacuate. The keywords, listens to instruction or gives an instruction were added as keywords to code if there is clear audio data that the individual instructs another person to act or if an individual moves to a doorframe, only after being instructed to do so.

A person may also communicate not to give instructions but to seek information, such as, asking about the event or wellbeing of another person. The keyword information seeking can be applied if there is audio evidence that the individual is seeking information.

4.5.7. Observation of the individual

The keywords not observable and re-enters frame had to be included to represent where there is no observable evidence of the behaviour of the individual. For example, if the individual exits the room and are no longer observable, or they are blocked from the view of the coder by another object or person. There were also instances where an individual would enter the fame after the shaking had begun, and therefore there was no knowledge of the individuals' prior activity or how this had changed in response to the event. The keyword enters frame, was developed to indicate the individual enters the frame during or after the earthquake shaking.

4.5.8. Earthquake attributes

4.5.8.1. Shaking Intensity

Shaking intensity is important because it provides context and reference for an individual's response (see Section 2.4.2). For example, an unnoticeable or barely perceptible earthquake may not be felt and therefore an individual continues their previous activity or if the individual is injured from a fall, or loses balance during the event, it may be because of high shaking intensity (see Figure 4.8). The energy released by an earthquake can be measured using magnitude; however this provides little information of the shaking impacts to people and the environment at the earth's surface. The Modified Mercalli Intensity scale (Dowrick et al. 2008) incrementally grades the impact of earthquake shaking on people from 1 to 11 and describes the observable effects on people and buildings (see Appendix D for the Modified Mercalli Intensity scale).

The inclusion of keywords to represent the shaking intensity using the Modified Mercalli (MM) scale allows the coder to observe the level of impact in the footage and apply the appropriate keyword. To apply MM keywords successfully, the coder must distinguish between the observed impacts on the environment and people in the footage, and the stability of the camera. For example, to code MM6, the coder must observe one or all of the instances described, such as difficulty in walking, pictures fall from walls, unstable furniture overturned etc.

A

Figure 4.8: Screen shots showing the difference in shaking intensity (A) This is considered MM4, low shaking intensity because shaking is felt indoors however no objects are displaced (HoldenManNZ 2010); (B) This is considered MM9, high shaking intensity, because a building is destroyed however the surrounding buildings remain relatively undamaged (hdp4ever1234567890 2011).

4.5.8.2. Shaking duration

Three keyword groups have been developed to specify the temporal component of the earthquake event: 'Pre-event', 'During event' and 'Post event'. Applying the keywords during the event indicates the duration of shaking the individual is exposed to.

4.6. Presenting coded data

To visually describe temporal-based response to earthquake shaking it was essential to use a tool that would relate the behavioural change of the individual to a timeline. In Transana, coded data is viewed using collection keyword maps. Collection keyword maps provide a graphical display of the keywords that has been applied (Woods and Fassnacht 2012). The keyword group and keywords that have been assigned to the data are shown as the vertical axis, along a horizontal timeline representing the length of the video in seconds. The colour bands represent keyword and the duration it has been coded for.

The following keyword maps are examples of the response of four individuals using the final coding scheme. The first example is fully explained as an example of how the keyword graphs should be interpreted.

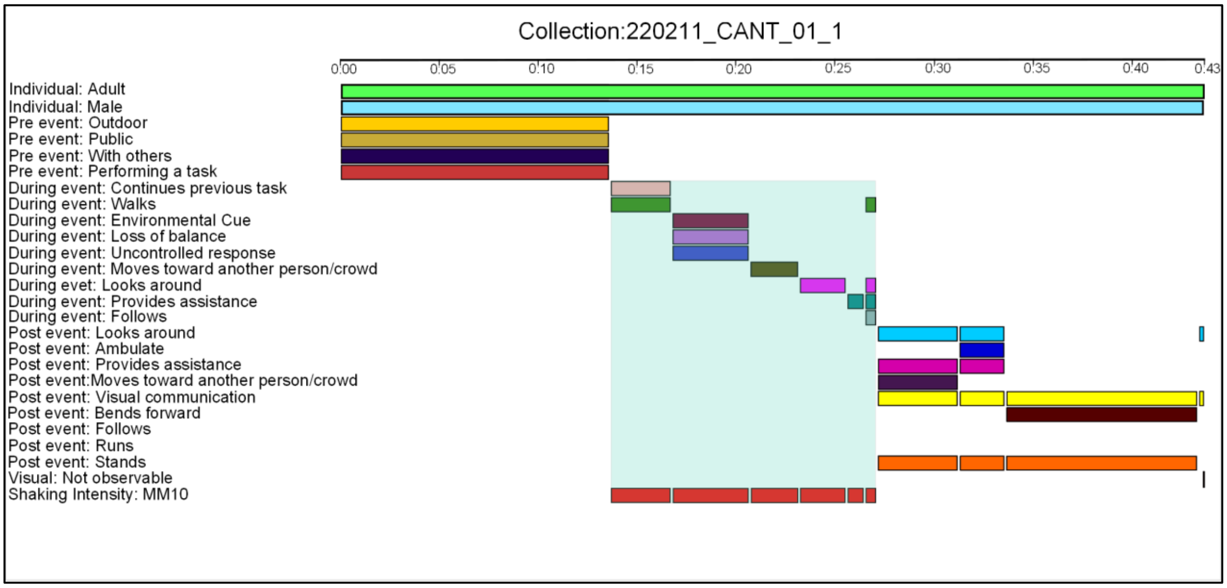


Figure 4.9: Keyword map showing the response of a male adult to the 22 February 2011event.

Figure 4.9 shows an adult male located outdoors in a public place before the earthquake event. This individual was with others performing a task. When the earthquake shaking began at approximately 14 seconds (blue shaded area represents duration), the individual initially continued previous activity and was walking. The individual did not change their activity after the shaking had begun for approximately 3 seconds. At this time the individual lost balance and behaved uncontrollably, likely due to strong earthquake shaking (MM10). The individual moved towards another person and looked around. The individual then simultaneously provided assistance, looked around, followed and walked during strong earthquake shaking (MM10). When the shaking stopped the individual continued to provide assistance, move toward another person/ crowd, look around and communicate with other individuals for approximately 5 seconds. The individual continued this activity but stops moving towards others and ambulates. The individual continued to communicate, stand and bend forward for approximately 8 seconds. The individual briefly looks around and communicates before becoming unobservable.

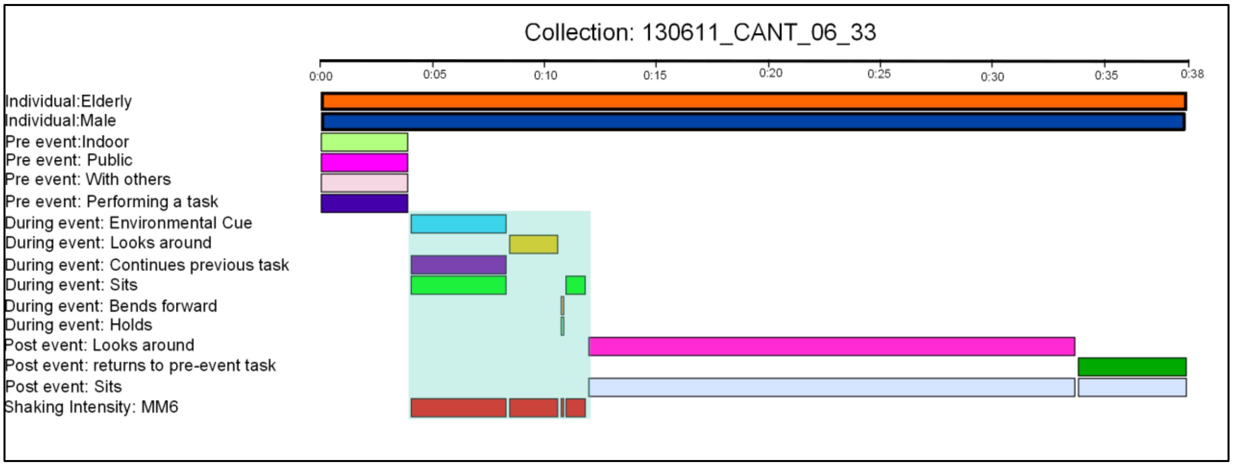


Figure 4.10: Keyword map showing the response of an elderly male to the 13 June 2011 event.

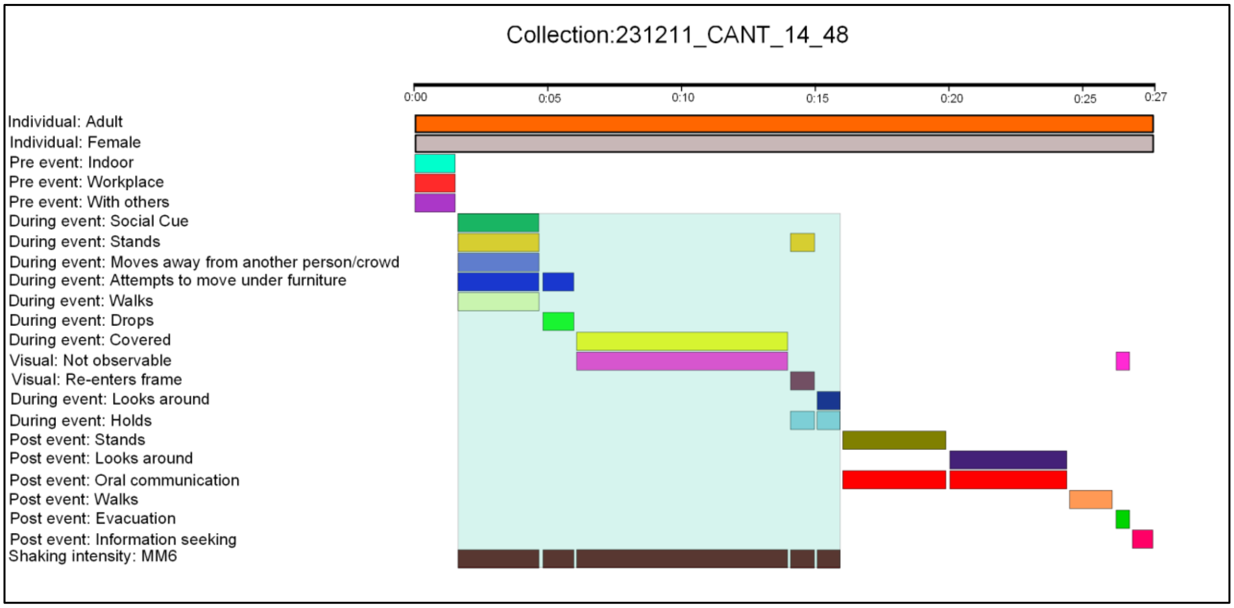


Figure 4.11: Keyword map showing the response of a female adult to the 23 December 2011 event.

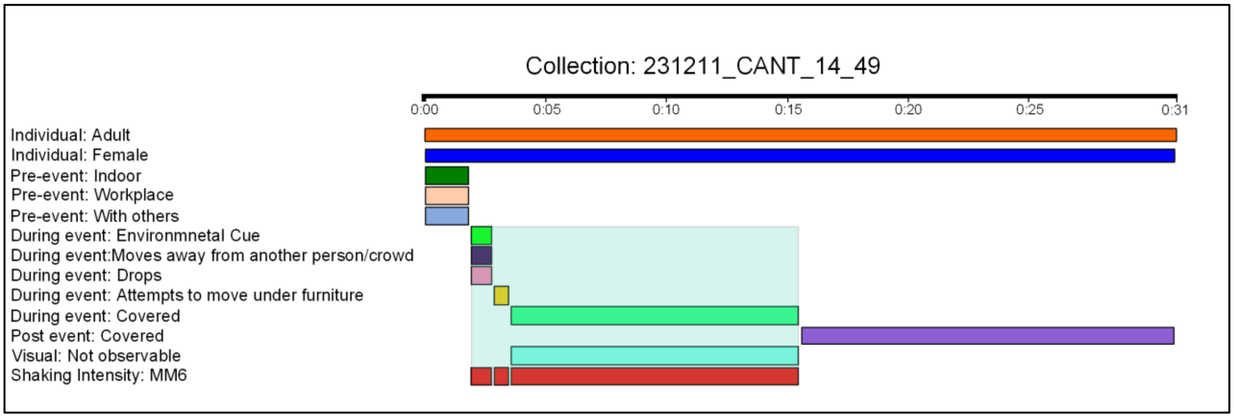


Figure 4.12: Keyword map showing the response of a female adult to the 23 December 2011 event.

The information that can be extrapolated from the coded data includes:

1. Individual characteristics such as, female, male and age group (non-time dependent)
2. The pre-event social and physical context such as, home workplace, alone or with others
3. Shaking intensity and duration (duration is shown in the shaded blue area)
4. The actions the individual engages in for example; whether they are injured; whether they protect themselves, whether they protect others, whether they evacuate etc.
5. Sequence of actions as the earthquake shaking progresses for example, the actions the individual took at the onset of shaking and the actions the individual took once the shaking had stopped
6. Repeated actions for example, how often the individual walked or looked around
7. Coupled responses for example; walks and moves toward another person; or runs and evacuates

Figure 4.9, Figure 4.10 and Figure 4.11 are three examples of individuals from different earthquake events (22 February 2011, 13 June 2011 and 23 December 2011) and have been provided to show the consistency in the application of the final coding scheme to videos of individuals in different locations, undertaking different actions and experiencing different shaking intensities. Figure 4.11 and Figure 4.12 are two examples of individuals from the same video file (23 December 2011) and have been provided to show how the coded data can be used to compare the response and activity of individuals in equal situations such as, the shaking duration and intensity, exposure to similar environmental hazards. For example, one individual immediately attempts to move under furniture and remains covered for the duration of shaking and immediately after shaking stops (see Figure 4.11). Comparatively, the individual in Figure 4.12 engages in more activity, takes approximately 4 seconds longer to seek protection and does not wait for the shaking to stop before looking around, standing and communicating.

The display of coded information through the use of keyword maps demonstrates how the coding scheme can be applied to compare the differences or similarities in the response of individuals across different earthquake events and in comparable earthquake events. Therefore, with further analysis of earthquake data and a large sample of individuals coded, these keyword maps will provide an evidence base to ask:

1. Were the Drop Cover and Hold recommendations followed, could protective action be performed? Is there a shaking intensity threshold that prompts certain responses?
2. To what extent is the response action dependent on the actions taken by other people present; the environment the individual is located, such as home or workplace; age and gender?
3. Does the person respond differently if they are alone or with others; are they likely to provide assistance to others present? To what extent does the presence of a child influence the response?

4.7. Summary

This chapter has presented the content and structure of the final coding scheme and described how the actual observations of earthquake footage informed the development of the keyword groups and keywords. The results of the coded data, shown as keyword maps, demonstrate the effectiveness of applying the coding scheme to earthquake footage to produce repeatable and interpretable results.

Chapter 5- Discussion and Conclusions

5.1. Introduction

The aim of Chapter 5 is to discuss the application and future use of the coding scheme in terms of how a large data set of coded earthquake footage may be interrogated and used to answer future questions relating to earthquake behaviour. This chapter will also discuss the limitations of observation analysis and data collection. It is structured as follows:

1. The first part of this chapter will discuss the independent use of the coding scheme and how it can be integrated with additional data.
2. The second part of this chapter will discuss the recommendations and ethical guidelines that are needed for future analysis of human behaviour.
3. The third part of the chapter presents conclusions of the thesis.

5.2. Application of the coding scheme

The CCTV Earthquake Behaviour coding scheme outlined in Chapter 4 describes individual response to earthquake shaking and provides context of the actions taken. Therefore the coding scheme can be used as a basis to record and analyse human behaviour during and immediately after earthquakes from multiple perspectives. The following table provides potential research perspectives and the types of information that could be explored.

Table 5. 1: Summary table of the type of research questions that could be used in future research

Behavioural Influence	Description	Sample Research Question	Potential application
Contextual Influences	This refers to the physical, social and environment setting of the individual at the time of earthquake shaking	In what physical setting are most people injured? Does movement during the event cause injury? What non-structural hazards are people exposed to? Are individuals slowed or prevented from performing any protective action because of spatial constraints? Are people more likely to be injured when alone or with others?	If the location of injuries is understood, this will provide prompt information of estimated casualties and welfare need of areas affected by an earthquake. This will also provide guidance for building design and configuration
Individual influences	This refers to age, gender and mobility impairments of the individual	What similarities and differences are there in gender and age response and injuries? How do individuals with mobility impairments, for example, individuals in a wheelchair protect themselves during and after earthquake shaking?	This will allow researchers to understand who is at risk of injury and therefore take measures to reduce the risk to injury

Behavioural Influence	Description	Sample Research Question	Potential application
Earthquake attributes	This refers to the shaking intensity and duration of the of the earthquake event	Is there a shaking intensity or shaking duration that prompts people to respond in certain ways, e.g. evacuate, rather that remain covered? Do people perform self-protective actions (i.e. “Drop, Cover, Hold”)? Does performing “Drop, Cover, Hold” make a tangible difference to the injuries sustained? If so, in what situation and environments?	This will contribute to future revisions of the content and objectives of actions to take at the onset of earthquake shaking and immediately following, for example advising people to freeze

The example research objectives in Table 5.1 show the potential application of the coding scheme from a range of disciplines. The following sections explain the research tasks that are necessary to achieve such levels of analysis.

5.2.1. Filter Categories

Filtering categories allow the researcher to focus on aspects of the coded data in isolation depending on the research question, and therefore create subsets of the larger data set (Lewins and Silver 2007). This would be particularly useful to explore the patterns and distribution of behaviour, such as injury, evacuation, and self-protective actions. The majority of computer based qualitative software packages contain search and retrieval tools. For example; a keyword search in Transana uses standard logical operators AND and OR, can search for multiple keywords, and allows nested logic (see Figure 5.1).

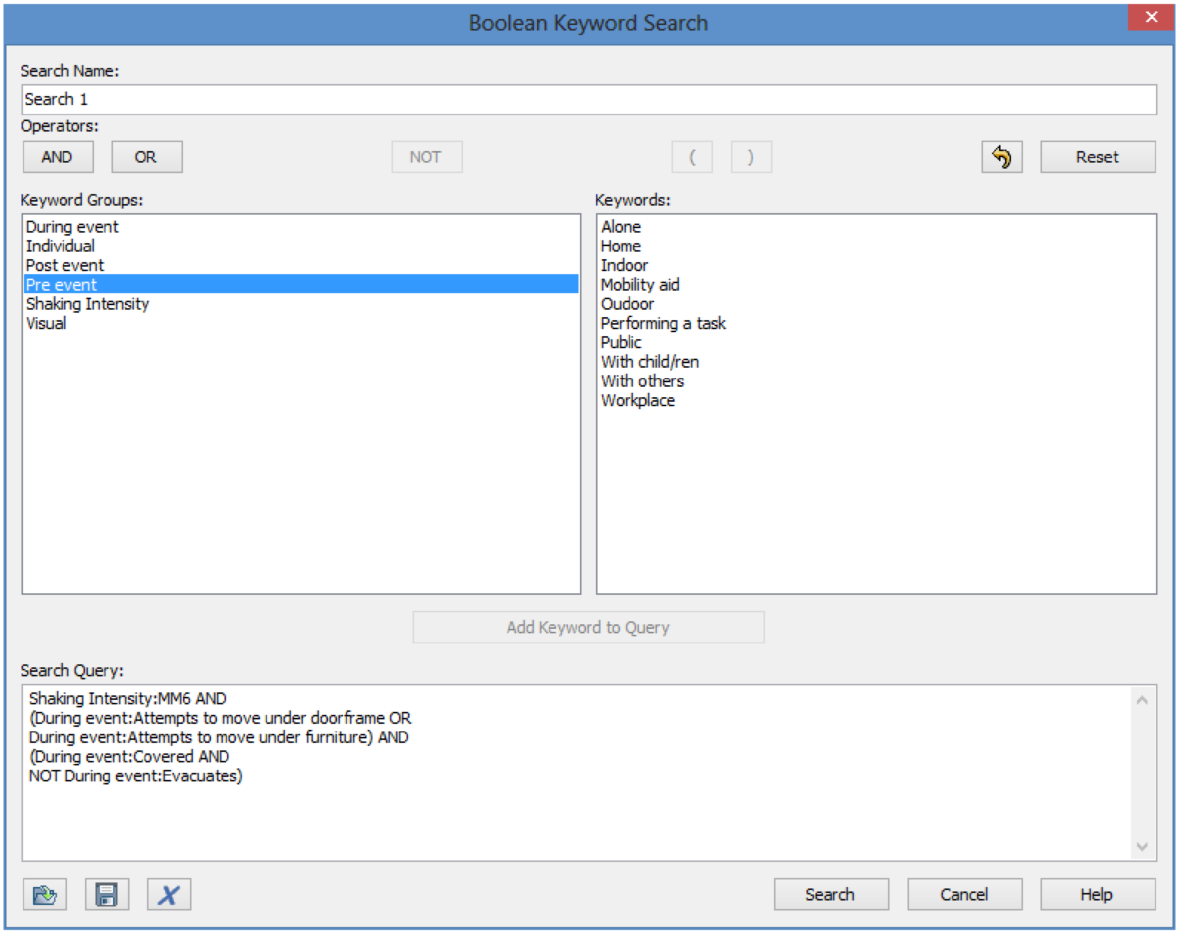
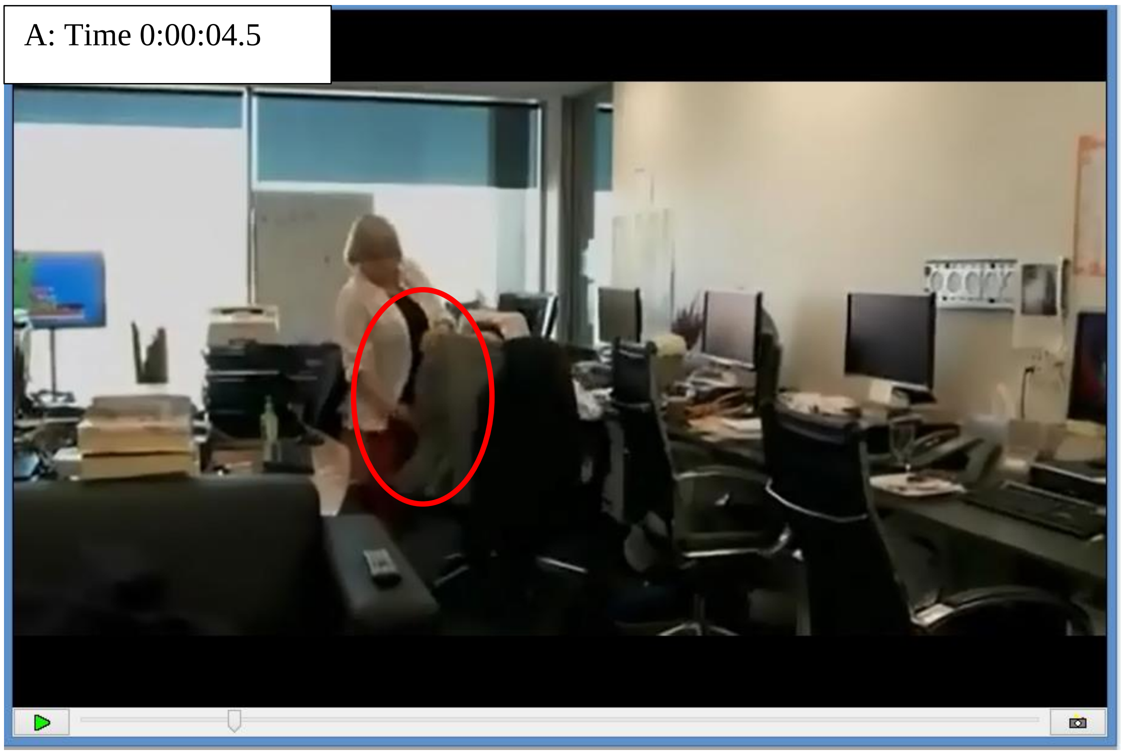


Figure 5.1: An example of the type of nested search that can be performed.

If a researcher is interested in the shaking intensity level and whether the individual attempted to move under furniture or a door frame and covered. This type of interrogation will allow researchers to explore how individuals use the environment to protect themselves. A researcher could also select the injury keywords and assess physical locations that individuals are likely to be injured such as, home or workplace, or the actions the individual engaged in that resulted in a particular level of injury such as, run, evacuate, and move toward another person. In this instance, there may be keywords that would benefit from further detail (Hsieh and Shannon 2005). For example, further detail of the physical location of the individual including; occupational use of the environment, such as kitchen or living area; the proximity to a doorframe or furniture; non- structural components that may be potentially hazardous, such as chairs or cabinets, may also be included into the coding scheme as keywords. Therefore if the causal factor of injury is being explored, researchers could explore how the location of an individual influences: the decision making process, time taken to respond and movement type.

For example in the screen shots in Figure 5.2 show a woman seeking shelter under a desk in response to the earthquake shaking. Although there is no observable impact or injury to her, the movement across the room could have resulted in an injury, such as a trip or fall. From an engineering and design perspective, the spatial constraints of an environment that slow or prevent the individual performing any protective-action could be explored. This would provide researchers with a better understanding of the context of injury in terms of what physical movement or environmental setting cause injuries.



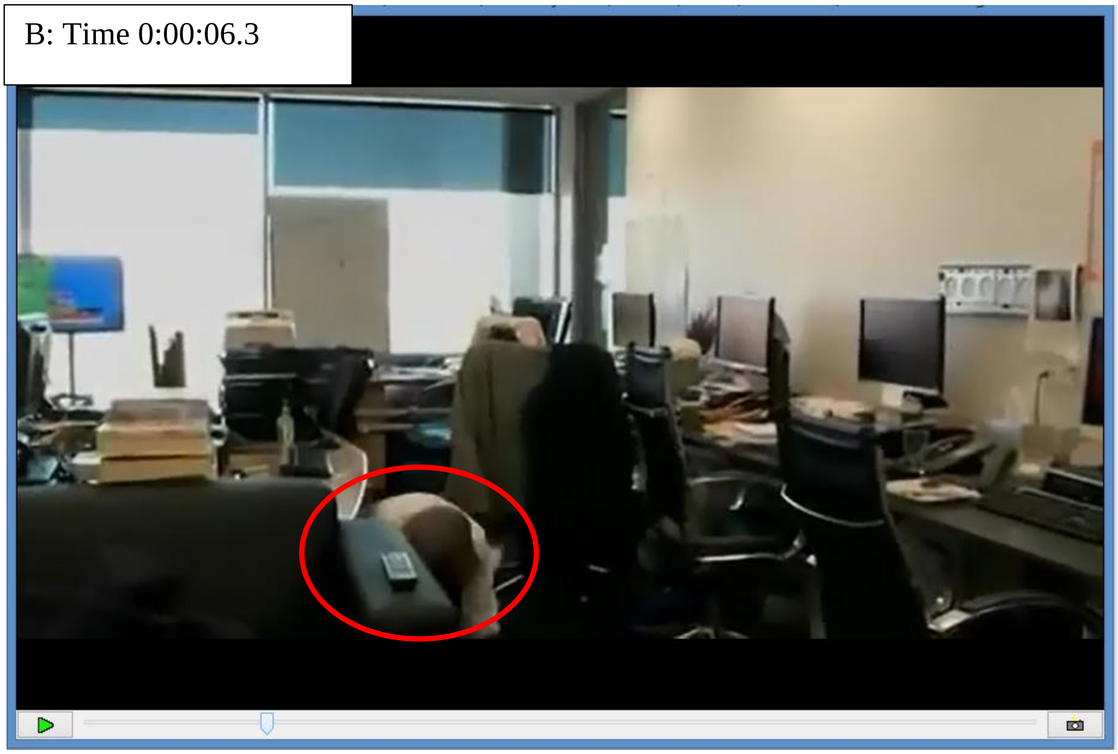


Figure 5.2: Screen shots showing (A) Woman in an office space responding to earthquake shaking, moving chair (B) Woman dropping to the ground to move under desk (The Telegraph 2011)

Filtering the data and creating subsets of the larger data set will allow researchers to selectively activate keywords and focus on combinations of themes identified in the data (Lewins and Silver 2007). The frequency that codes have been applied can then be converted to numerical value. For example the frequency that individuals were injured in particular environment, or the frequency that individuals performed any self-protective action given a certain shaking intensity level. Therefore, with a large data set of coded individuals, the coding scheme can be used as an assessment tool to analysis patterns and distribution of behaviour and provide guidance for building design and configuration and evidence based recommendations for public education about injury-preventing behavioural responses during and immediately following earthquake shaking (see Table 5.1).

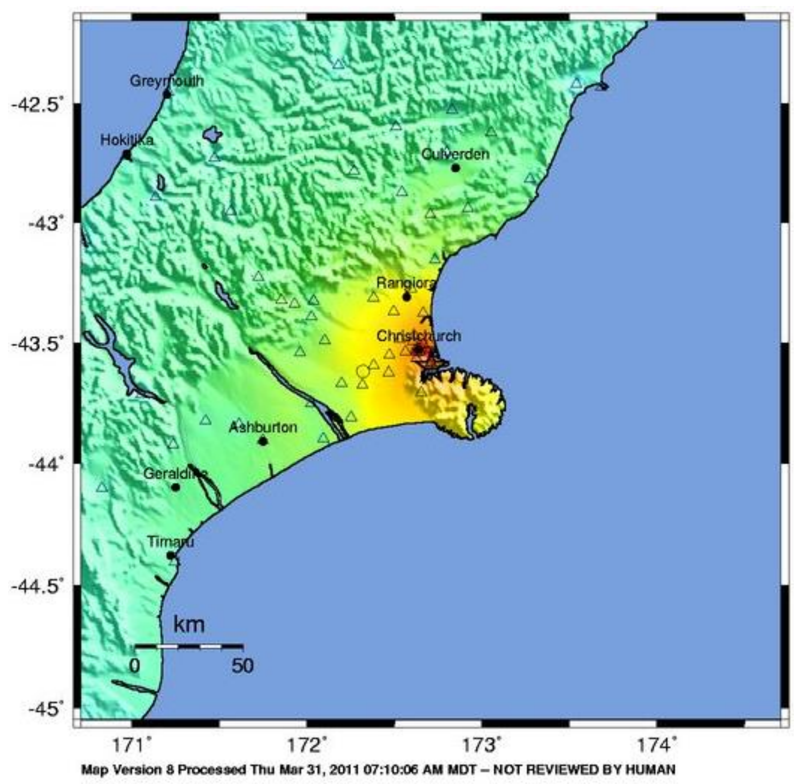
5.2.2. Combining tertiary data

The filtering tool could be further enhanced by combining the results of a search with additional tertiary data that are not directly available through video observation analysis. This would provide researchers, emergency management and policy makers with a more in-depth understanding of behaviour. Examples of tertiary data and the types of information that may be used are summarised in Table 5.2 for the ensuing discussion.

Table 5.2: Summary of the type of additional tertiary data that may be incorporated with coded video footage

Tertiary data	Source	Example information
GPS data	This could be available if the camera is equipped with GPS	The exact location of the individual
Socio-economic data	Statistics New Zealand Council records Company records	Population, income, education, employment
Technical data *e.g. using structural and geotechnical site investigations*	Historical council records Post-earthquake building and damage investigations Seismic vulnerability assessments Forecast ground shaking intensities for earthquake risk management	Seismic damage assessment of industrial and residential structures using bore logs and Cone Penetration Test (CPT) results. Building age and construction type
Seismic data	Shake map (source for all international earthquakes) GeoNet (source for all New Zealand earthquakes)	Magnitude, Peak Ground Accelerations, MM shaking intensity, and the exact time of the event

If researchers collected security footage from every supermarket, hospital or shopping complex located at different regions of a city and used the CCTV Earthquake Behaviour coding scheme to inform the response of individuals and what levels of injuries were sustained in different areas, the results could be combined with tertiary data in a number of ways. For example, If the exact location of the individual was known using GPS data, the coded behaviour data could be collated in an integrated geocoded database. This would be particularly useful to understand in what environments are individuals likely to be injured and therefore contribute to accurate casualty modelling. Socio-economic data will provide researchers with population statistics and area unit boundaries. Researchers could then perform social inequality analysis and identify communities that are most vulnerable and consider how public education, in terms of earthquake preparedness campaigns, could be channeled to those vulnerable communities. Technical data will provide researchers with information of building age and construction type as well as expected performance in different shaking conditions. For example, researchers could analyse how building height influences the behaviour of individuals and therefore identify buildings and occupants who are most vulnerable. This could contribute to appropriate building plans, in terms of design, configuration and regulations. Furthermore the addition of seismic data will provide researchers with actual recorded ground motion information. For example researchers could combine coded data with information of shaking intensities levels using an earthquake intensity forecast map, such as Shake Map from the United States Geological Survey (Figure 5.3).



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Figure 5.3: Shake Map of the 22 February 2011 ‘Christchurch’ event which affected Christchurch , New Zealand, showing additional seismic data that can be used (USGS ShakeMap 2014).

The isoseismal lines that can be extracted from a Shake Map represent areas of equal shaking. Therefore, by overlaying the isoseismals of an earthquake intensity forecast map over demographic information in a Geographical Information System (GIS) scientists or emergency managers could match this to video analysed using CCTV Earthquake Behaviour coding scheme to observe how behavior may change as a function of shaking intensity. For example it could be investigated what behaviour is undertaken in areas of high shaking intensities, such as running and evacuating and how these behaviours cause injury. This type of information would contribute to controls for building development and land use. Furthermore, by combining seismic data researchers could also identify areas that are of greater risk to future seismic hazards. Thus, improve emergency response to those areas, in terms of arrival time of search and rescue teams and welfare aid and prepare health care providers for expected earthquake casualties.

Therefore, combining additional tertiary data to a large data set of coded individuals would allow researchers to organize behaviour according to equal conditions including: individuals who are exposed to equal shaking intensity; individuals who are exposed to equal shaking duration; individuals who are exposed to equal structural hazards and thus, allow cross-event analysis.

5.3. Limitations of observation analysis

The coding scheme has been developed with the potential for accurate inter-coder reliability with the use of descriptors, relevance statements, and justifications to help guide each coder in the application of keywords. However, there remains some level of subjectivity associated with the application of keywords. Thus, coder training will be required to ensure inter-coder reliability and objective observation of the video data (see Appendix C for general instructions for video analysis in Transana and a worked example of video observation). Training can be taken as a measure to reduce inconsistencies in coding however the following sections describe the unavoidable limitations associated with observation analysis.

5.3.1. Video Quality

Applying keywords accurately depends on the quality of the video. Power outage and loss of light during the event may reduce the continuity of the footage or the individuals may be pixilated due to a low resolution camera (see Figure 5.4).

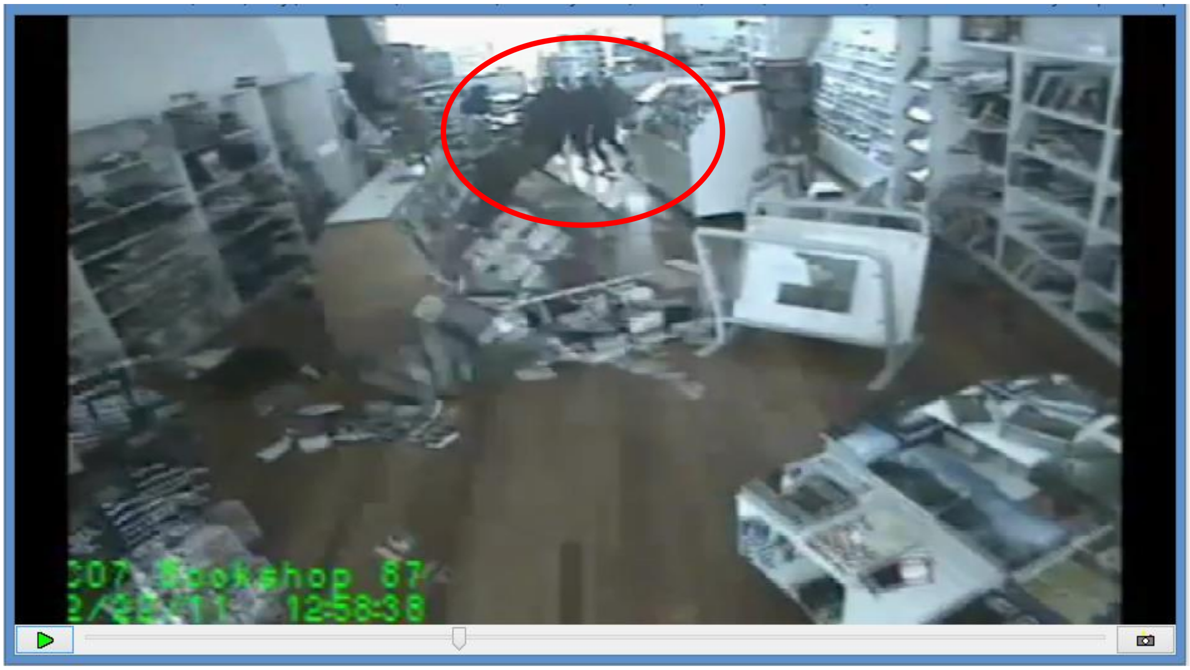


Figure 5.4: Screen shot showing the difficulty a coder may have in applying keywords to the individuals at the top of the screen in terms of their identity and the response actions they take (Christchurch Art Gallery 2011)

Poor video quality requires some level of judgment of the coder in the application of the keywords, including: determining individual characteristics, such as age and gender; actions that the individuals take; whether the movement is beyond the control of the individual; and earthquake attributes.

5.3.2. Still camera angle

Accurate observation is also difficult with the still camera angle. Individuals may exit the view of the coder, either by exiting the frame or being blocked by other people or objects or may be in the distance (see Figure 5.3). The still camera angle may limit the visual contact and result in the difficulty described in Section 5.3.1.

5.3.3. Timing accuracy

Time codes are used to synchronize points in the transcripts to points in the video. Time stamps represent the start and end points of an action and therefore the duration they were performed for (see Figure 3.2). Time stamps are not automatic and therefore there is a level of coder judgment required. It may be difficult to insert time codes exactly if the observed individual rapidly changes their actions and may potentially lead to cumulative error. However this error would be less than a second because of human judgment accuracy, and therefore considered to be minor.

5.4. Limitations of data collection

One of the major limitations identified in this thesis was the absence of reliable data storage and data management of video footage following earthquake events. As mentioned in Chapter 3, organisations that were approached for earthquake footage had lost data of the actual shaking due to a combination of: power loss during the event; reductive deletion, where the quality of the video is gradually reduced to save storage space; or had not automatically saved the footage following the event. This resulted in considerable data loss and highlighted the need for owners of video data to be prompted to save footage following the event to avoid future data loss.

There were also limitations identified in the process of ethical application for video data. Responsible authorities were reluctant to provide access to data, given their obligation to maintain the privacy of personal information that could be identified. The primary concerns were:

1. The practical difficulties in obtaining consent from the individuals due to lack of contact information. For example, staff members who had left since the earthquake event and therefore could not be informed of the research or provide consent to participate.

2. Who would have access to the data and how the individuals would be identified.

3. How the data would be securely stored and what length of time it would be needed for.

Further discussion of the ethical use of data is presented in Section 5.5.2. The limitations discussed in this section highlighted issues that may be encountered in future analysis therefore, the following recommendations are made.

5.5. Recommendations

To avoid data loss following an earthquake event and to ensure fluent ethical application of earthquake footage, future research requires development of guidelines for data storage and procedures for ethical use of video data. With guidelines and ethical procedures, researchers will be able to collect all possible occurrences of human behavior from multiple sources, such as malls, supermarkets, hospitals and universities. Therefore, it is recommended that the creation of a database of all existing earthquake footage and a systematic recording and inventory system be established. It is also recommended that the method of data collection, processing and analysis used in this research be used as a guideline for all future analysis so that any cross analysis will have compatible databases (see Table 5.3).

Owners of video data need to be prompted to save data following an event. This will not automatically mean data is available to researchers; however it will mean that data is not lost. The application for video data would then be possible in the months following the earthquake event (see Figure 5.5)

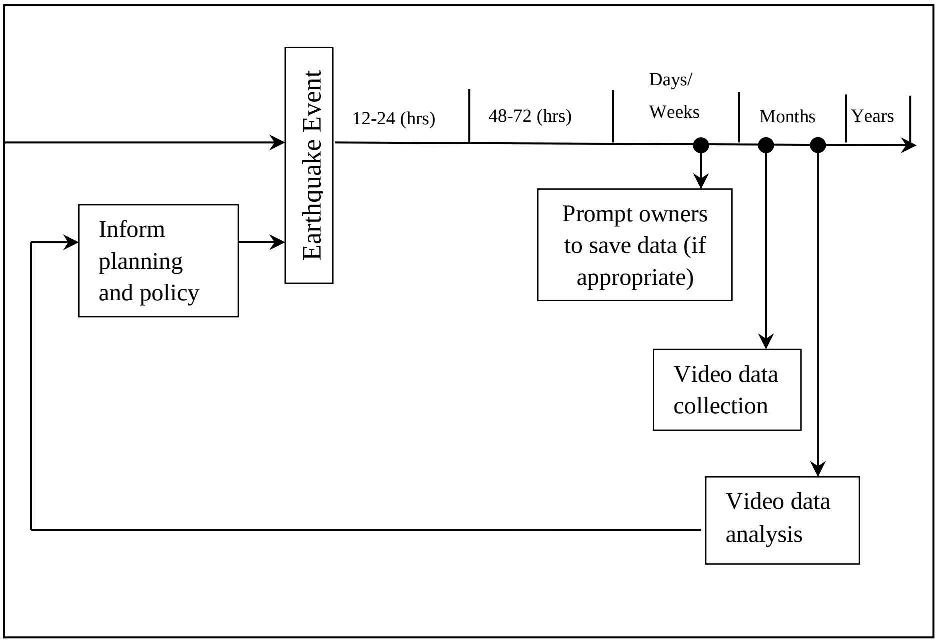


Figure 5.5: Schematic of the time frame that video data should be collected to avoid data loss

5.5.2. Ethical application and treatment of data

In New Zealand, as in most other jurisdictions, social science is governed by ethical guidelines. This will be important for researchers to consider because the use of CCTV data to analyse response to earthquake shaking goes beyond the purposes the data were collected for. Individuals also expect the collection of personal information to be deleted; therefore there is an obligation from responsible authorities not to distribute the data to researchers. Due to these obligations, the identification of individuals, access to data, data storage must be considered prior to data collection.

Access to CCTV data will require approval from data owners. It should be made clear in the ethics application the expected time the raw data will be held for; how the identification of individuals will be treated; what access is required, such as, length of video needed; who has access to the coded data; who will have access to the raw data and how the data will be securely stored. The ethics application is entirely dependent the research questions and the amount of data to be analysed, in terms of length it will be needed for. Researchers must also be committed to maintaining the protection of the personal information of the individual. It is recommended that the approach to identify individuals in this research be used as they are only identifiable by a unique code (see Table 3.2).

Therefore with ethical management of the video data, in terms of data storage and caution of the identification of individuals, the use of public area CCTV imagery should be considered as a potential resource for future analysis of human behaviour research.

5.5.3. Guidelines for future analysis

The following table provides a summary of the main research tasks that were undertaken in this research and future needs for data analysis. This table should be used as guidelines of all future research of human response to earthquake shaking.

Table 5.3: Guidelines for tasks of future research analysis

Research task		Methodology
Documentation of earthquake video data	1. Application of ethics	- Use the set requirements of the institution or university Human Ethics Committee
	2. Create database	In addition to those recorded in this research, compile existing earthquake footage and update the database when data is available.
Documentation of earthquake video data	3. Data processing	- Use the process developed in this thesis to: (a) record all relevant earthquake video data e.g. Date_earthquake_# (see Table 3.2) - (b) manage and store the data (see section 3.6)

Research task		Methodology
Data Analysis	1. Qualitative analysis of video data	- (c) transcribe each individual e.g. Date_earthquake_#_#(see Table 3.2) - (d) code the video data using the final coding scheme
	2. Interrogate coded data	Stratify behavior as a function of physical environment (see section 5.2.1). Organise behaviour according to equal conditions (see section 5.2.2)

5.5. Conclusions

This thesis aimed to develop a process for analysing earthquake video data and to develop a robust coding scheme of actual observations of human behavior.

The methodological approach combined a deductive and inductive process of analysis to iteratively develop the coding scheme from earthquake behaviour cited in previous literature and observations of actual footage from the Canterbury earthquake sequence. This combined approach meant that the video data were frequently transcribed and coded resulting in the reviewing, regrouping and rethinking of the keyword groups and keywords. The final coding scheme remains close to the source data and contains only observable information of the individual. Thus, the final coding scheme removes the subjectivity that is inherent with post-event, reflective interview and questionnaire studies (see Chapter 2) and provides researchers with a systematic methodology to analyse actual human response during and immediately following earthquake shaking. It will benefit from application in other settings to allow iterative improvement.

The types of information that can be extrapolated from the independent use of the coding scheme include: individual characteristics, pre-event social and physical context, the response of the individual during the shaking; the response of the individual immediately after; and the shaking intensity and duration that the individual was exposed to (see Section 4.6). As discussed in this chapter, coded data can also be filtered and combined with additional tertiary data that may be available. With this level of analysis researchers can look specifically at the patterns and distributions of behaviour from engineering, educational, and health care perspectives.

Therefore, a large data set of coded information will provide empirical evidence to inform industrial building design and configuration, for example warehouses, super markets and office spaces and contribute to future revisions of public education strategies about injury-preventing behavioural response during and immediately following earthquake events.

References

Absfam10 (2011 December 23) Christchurch quake 23 Dec 2011 6.03.18pm.mp4 [video file]. Retrieved from: http://www.youtube.com/watch?v=CBofg9QMgEw .Accessed 10 May 2013

Afitska O (2009) Review of Transana 2.30. *Language Documentation and Conservation*. 3:226–235.

Alexander D (1990) Behaviour during earthquakes: A southern Italian example. *International Journal of Mass Emergencies and Disasters.* 8:5–29.

AndrewHuntley (2011 December 23) More Christchurch Earthquakes 23 December 2011 [video file]. Retrieved from http://www.youtube.com/watch?v=3Zzewm3HKE8 Accessed 8 May 2013

Archea J, Kobayashi M (1984) The Behaviour of people in dwellings during the Off-Urakawa earthquake of March 21, 1982. Proceedings of the eighth world Conference of Earthquake Engineering. V5. Prentice-Hall, INC, pp 1101–1107

Ardagh MW, Richardson SK, Robinson V, et al. (2012) The initial health-system response to the earthquake in Christchurch, New Zealand, in February, 2011. *Lancet* 379:2109–15. doi: 10.1016/S0140-6736(12)60313-4

Aroni S, Durkin M (1985) Injuries and occupant behavior in earthquakes. Joint US-Romanian Seminar on Earthquakes and Energy, Bucharest, Romania. Architectural Research Centers Consortium, Washington, DC, 2:3–40

Badreddine Z, Buty C (2011) Discursive Reconstruction of the Scientific Story in a Teaching Sequence. *International Journal Science Education*. 33:773–795. doi: 10.1080/09500693.2010.496475

Bannister S, Gledhill K (2012) Evolution of the 2010–2012 Canterbury earthquake sequence. *New Zealand Journal of Geology and Geophysics* 55:295–304. doi: 10.1080/00288306.2012.680475

Bödvarsdóttir I, Elklit A (2004) Psychological reactions in Icelandic earthquake survivors. *Scandinavian Journal of Psychology* 45:3–13.

Bourque L, Russell L, Goltz J (1993) Human behaviour during and immediately after the earthquake. . In P.A. Bolton (ed) *The Loma Prieta, California, Earthquake of October 17, 1989: Public Response*, Professional Paper 1553-B Washington DC: U. S. Geological

Survey. pp. B3-B22. Available at pubs.usgs.gov/pp/pp1553/pp1553b/

Cardeña E, Spiegel D (1993) Dissociative reactions to the San Francisco Bay Area earthquake of 1989. *American Journal of Psychiatry* 150:474–8.

Christchurch Art Gallery (2011 December 7) Christchurch Art Gallery Shop earthquake footage [video file]. Retrieved from: http://www.youtube.com/watch?v=eM_l3uc15GY Accessed 8 May 2013

Cocking C, Drury J, Reicher S (2009) The psychology of crowd behaviour in emergency evacuations: Results from two interview studies and implications for the Fire and Rescue Services. *Irish Journal of Psychology.* 30:59–73. doi: 10.1080/03033910.2009.10446298

Corbin J, Strauss A (2008) Basics of Qualitative research, 3rd ed. Sage Publications, Inc.

Cornwell B (2003) Bonded Fatalities : Relational and Ecological Dimensions of a Fire Evacuation. *The Sociology Quarterly*. 44:617–638.

De Bruycker M, Greco D, Lechat, M F, et al. (1985) The 1980 earthquake in Southern Italy--morbidity and mortality. *International Journal of Epidemiology.* 14:113–7.

Dempster PG, Woods DK (2011) The Economic Crisis Though the Eyes of Transana. *Forum of Qualitative Social Research.* 12:1 Retrieved from: http://www.qualitative-research.net/index.php/fqs/article/view/1515/3127

Dowrick DJ, Hancox GT, Perrin ND, Dellow GD (2008) The Modified Mercalli Intensity scale revisions arising from New Zealand experience. *Bulletin of the New Zealand Soiciety for Earthquake Engineering.* 41:193–205.

Drury J, Cocking C, Reicher S (2009) The Nature of Collective Resilience: Survivor Reactions to the 2005 London Bombings. Int J Mass Emerg Disasters 27:66–95.

dty2dty2 (2011 February 22) Aftershock 22Feb2011 [video file]. Retrieved from: http://www.youtube.com/watch?v=OjZNTvVJLiw&list=PL0C341A0D3893EB9B Accessed 6 May 2013

Dyers Road ITM (2011 June 15) Christchurch Earthquake Dyers Road ITM [video file]. Retrieved from: http://www.youtube.com/watch?v=O2WNYdW8vEo. Accessed 10 May 2013

Gawith E (Libby) (2013) The on-going psychological toll from the Canterbury earthquakes: Stories from one community. *Disaster Prevention Management*. 22:395–404. doi: 10.1108/DPM-10-2013-0180

Glass RI, Urrutia JJ, Sibony S, et al. (1977) Earthquake Injuries Related to Housing in a Guatemalan Village. *Science, New Series.* 197:638–643.

Goltz JD, Mileti DS (2011) Public Response to a Catastrophic Southern California Earthquake: A Sociological Perspective. *Earthquake Spectra* 27:487–504. doi: 10.1193/1.3575728

Goltz JD, Russell LA, Bourque LB (1992) Initial behavioural response to a rapid onset disaster: A case study of the October 1, 1987 Whittier Narrows earthquake. *International Journal of mass Emergencies and Disasters.* 43–69.

hdp4ever1234567890 (2011 April 4) New CCTV Footage of the Christchurch earthquake [video file]. Retrieved from: http://www.youtube.com/watch?v=duoS7hwJlrU Accessed 8 May 2013

HoldenManNZ (2010 September 4) Christchurch 5.0 strong aftershock [video file]. Retrieved from: http://www.youtube.com/watch?v=DkaWv-iJDw4&list=PL0C341A0D3893EB9B&index=31 Accessed 6 May 2013

Hsieh H-F, Shannon SE (2005) Three approaches to qualitative content analysis. *Qualitative Health Research.* 15:1277–88. doi: 10.1177/1049732305276687

Johnston D, Standring S, Ronan K, et al. (2014) The 2010/2011 Canterbury earthquakes: context and cause of injury. *Natural Hazards*. doi: 10.1007/s11069-014-1094-7

Kanter RK (2010) Child Mortality After Hurricane Katrina. *Disaster Medecine and Public Health Preparedness* 4:62–65. doi: doi:10.1017/S1935789300002433

Koopman C, Classen C, Spiegel D (1996) Dissociative Responses in the Immediate Aftermath of the Oakland/Berkeley *Firestorm. Journal of Trauma Stress.* 9:521–540.

Koyama M, Okada S, Ohta Y (2011) Major Factors Controlling Earthquake Casualties as Revealed via a Diversified Questionnaire Survey in Ojiya City for the 2004 Mid-Niigata Earthquake. In: Spence R, So E, Scawthorn C (eds) Human Casualties Earthquakes. Springer Netherlands, pp 199–217

Lewins A, Silver C (2007) Qualitative Coding in Software: Principles and Processes. Using software in qualitative research. Using Software in Qualitative Research. doi: 10.4135/9780857025012

Lindell M, Prater C, Wu H, et al. (2014) Immediate behavioural Response to Earthquakes in Christchurch New Zealand and Hitachi Japan. Manuscript submitted for publication.

Lindell MK, Perry RW (2012) The Protective Action Decision Model: Theoretical Modifications and Additional Evidence. *Risk Analysis* 32:616–632. doi: 10.1111/j.1539-6924.2011.01647.x

Liston K (2010) A Mediated Interaction Approach to Study the Role of Media Use in Team Interaction. Centre for integrated facility Engineering. Stanford University.

Mahue-Giangreco M, Mack W, Seligson H, Bourque LB (2001) Risk factors associated with moderate and serious injuries attributable to the 1994 Northridge Earthquake, Los Angeles, California. *Annals of Epidemiologyy* 11:347–57.

Mavrou K, Douglas G, Lewis A (2007) The use of Transana as a video analysis tool in researching computer-based collaborative learning in inclusive classrooms in Cyprus. *International Journal of Research and Method in Education.* 30:163–178. doi: 10.1080/17437270701383305

Mawson AR (2005) Understanding mass panic and other collective responses to threat and disaster. *Psychiatry* 68:95–113.

Ohta Y, Ohashi H (1985) Field survey on occupant behaviour in an earthquake. *International Journal of Mass Emergencies and Disasters.* 3. pp. 147-160.

Peek-Asa C, Ramirez M, Seligson H, Shoaf K (2003) Seismic, structural, and individual factors associated with earthquake related injury. *Injury Prevention.* 9:62–66.

Petal M (2009) Evidence-based public education for disaster prevention: causes of deaths and injuries in the 1999 Kocaeli earthquake. VDM Verlag Dr. Müller, Saarbrücken

Petal M (2011) Earthquake Casualties Research and Public Education. In: Spence R, So E, Scawthorn C (eds) Human Casualties in Earthquakes: Progress in modelling and mitigation. Springer Netherlands, pp 25–50

Pomonis A, Coburn AW et al. (1992) Part three: casualty estimation in the collapse of reinforced concrete buildings, human casualties in building collapse – second year report, Cambridge, UK, pp 33–45

Porter K, Shoaf K, Seligson H (2006) Value of Injuries in the Northridge Earthquake. *Earthquake Spectra* 22:555–563. doi: 10.1193/1.2194529

Prati G, Catufi V, Pietrantoni L (2012) Emotional and behavioural reactions to tremors of the Umbria-Marche earthquake. *Disasters* 36:439–451. doi: 10.1111/j.1467-7717.2011.01264.x

Prati G, Saccinto E, Pietrantoni L, Pérez-Testor C (2013) The 2012 Northern Italy Earthquakes: modelling human behaviour. *Natural Hazards* 69:99–113. doi: 10.1007/s11069-013-0688-9

Quarantelli EL (1999) Sociology of panic, Preliminar. Disaster Research Center, University of Delaware

Ramirez M, Kano M, Bourque L, Shoaf KI (2005) Child and Household factors associated with fatal and non fatal pediatric injury during the 1999 Kocaeli earthquake. *International Journal of mass Emergencies and Disasters.* 23:129–147.

Richardson S, Sci DH, Teach DT, et al. (2013) A moment in time : emergency nurses and the Canterbury earthquakes. *International Nursing Review.* 188–195.

Rosoff H, John R, Burns WJ, Maya I (2011) Scenario Simulation Group Reactions to the Aftermath of the Great ShakeOut Magnitude 7.8 Earthquake. *Earthquake Spectra* 27:597–614. doi: 10.1193/1.3574450

Shoaf KI, Sareen HR, Nguyen LH, Bourque LB (1998) Injuries as a Result of California Earthquakes in the Past Decade. *Disasters*. 22:218–235. doi: 10.1111/1467-7717.00088

Solberg C, Joffe H, Rossetto T (2008) How people behave in anticipation of and during earthquakes: A review of social science literature on what drives this behaviour. Paper presented at the 14th world conference on earthquake engineering, Beijing, China

Spence, R., So, E., & Scawthorn, C. (2011). *Human Casualties in Earthquakes: Progress in Modelling and Mitigation*. (R. Spence, E. So, & C. Scawthorn, Eds.). Dordrecht: Springer Netherlands. doi:10.1007/978-90-481-9455-1

Spiegal, D., Cardeña, E. (1991). Disintegrated experiences: The dissociative disorder redefined. *Journal of Abnormal psychology*. 100. 366-378

Strauss A, Corbin J (1990) Basics of Qualitative research: Grounded theory procedures and techniques. Sage Publications, Inc.

Suhail K, Malik F, Mir I a., et al. (2009) Psychological Health of Earthquake Survivors in Pakistan. *Psychology and Developing Societies*. 21:183–207. doi: 10.1177/097133360902100202

The Telegraph (2011 December 23) New Zealand Large earthquake rocks Christchurch [video file] Retrieved from: http://www.youtube.com/watch?v=U2R-l6ex5u8 Accessed 6 May 2013

Turner R, Killian M (1972) Collective Behaviour, 2nd ed. 435.

USGS ShakeMap (2014) Retrieved January 17, 2014 from: http://earthquake.usgs.gov/earthquakes/shakemap/global/shake/b0001igm/). Accessed 17 February 2014

USGS World Deaths (2014) Retrieved February 10, 2014 from: http://earthquake.usgs.gov/earthquakes/world/world_deaths.php. Accessed 17 February 2014

Wendy84457 (2011) Home CCTV Video [video file] Retrieved from: http://www.nzherald.co.nz/video/news/video.cfm?c_id=1501138&gal_cid=1501138&gallery_id=123226. Accessed 6 May 2013

WakeUpWord (2011 June 13) Raw video 5.5 quake hits during Christchurch Powhiri [video file]. Retrieved from: http://www.youtube.com/watch?v=OvcaMkDatko. Accessed 6 May 2013

Woods D, Fassnacht C (2012) Transana Version 2.53. In: Madison, WI Board Regents Univ. Wisconsin Syst. http://www.transana.org/. Accessed 22 April 2013

Appendix A-Provisional Coding Scheme

Table A.1: Provisional Coding scheme developed from key themes identified in the literature review

Keyword Group	Keyword	Description	Reference	Relevance
Action	Resumes previous activity	Individual returns to previous activity	(Ohta and Ohashi 1985)	Do people notice the earthquake and return to previous tasks?
	Protects self (Dropped and Covered)	Individual performs drop cover and hold	(Archea and Kobayashi 1984; Goltz et al. 1992; Bourque et al. 1993; Rosoff et al. 2011; Prati et al. 2012; Prati et al. 2013)	Do people follow recommended advice? Do people Drop Cover Hold?
	Looks around, delayed response	Individual looks around		
	Information Seeking	Individual looks for information		
	Running	Individual runs	(Alexander 1990)	
	Walking	Individual walks		
	Stops driving, pulls to the side of the road	Individual stops driving and pulls over to the side of the road	(Goltz et al. 1992)	
	Stops previous activity	Individual stops previous activity but takes no action		
	Evacuates	Individual evacuates	(Ohta and Ohashi 1985; Alexander 1990; Goltz et al. 1992; Bourque et al. 1993; Rosoff et al. 2011; Prati et al. 2012; Prati et al. 2013)	

Keyword Group	**Keyword**	**Description**	**Reference**	**Relevance**
Action	Tries to protect property	Individual tries to protect property	(Archea and Kobayashi 1984; Prati et al. 2012)	Do people try to protect property?
	Provides assistance	Individual helps another person to safety or comforts another person	(Bourque et al. 1993; Prati et al. 2012)	Do people protect others before themselves?
	Receives assistance	Individual receives help or comfort from another person		
Behavioural Response	Fight	Individual responds appropriately/ Takes protective action		What is the most common behavioural response?- individually. Do earthquakes trigger primitive responses?
	Freeze	Individual takes no action	(Goltz et al. 1992; Bourque et al. 1993; Prati et al. 2012)	
	Flight	Individual does not respond appropriately/ Does not take a protective action	(Alexander 1990)	
	Affiliation	Individual seeks the proximity of familiar persons / places	(Mawson 2005; Prati et al. 2012)	What is the most common behavioural response?- collectively
	Ambulate	Individual moves from place to place		

Appendix B- CCTV Human Response to Earthquake Shaking Coding Scheme

Table B.1: CCTV Human Response to Earthquake Shaking Coding Scheme

Keyword Group *(Category)*		Keyword *(Code)*		Description	Reference	Relevance	Justification
		Low resolution	**High resolution**				
Contextual data (non-time dependent)	**Individual**	Age 1 (<5 years)	1.1 infant	Estimated ages 0 up to but not including 1	(Goltz et al. 1992; Bourque et al. 1993; Mahue-Giangreco et al. 2001; Peek-Asa et al. 2003; Ramirez et al. 2005a; Kanter 2010)	What differences/ similarities are there when comparing age and gender responses?	Studies report age increments of 10-20 years providing little insight into the differences of behaviour between infants, toddlers, school age children and adolescents. This is important because so much of human behaviour is related to their age, situational awareness and their mobility therefore affecting their ability to respond to an event. Thus, age is categorized based on physical and educational development. In some instances determining the age of an individual will be difficult, e.g. if the video quality is poor, for this reason
			1.2 Pre-school age	Estimated ages 1-5			
		Age 2 (6-18 years)	2.1 Primary school age	Estimated ages 6-10			
			2.2 Secondary school age	Estimated ages 11-18			
		Age 3 (19+ years)	3.1 Adult	Estimated ages 19-64			
			3.2 Elderly	Estimated ages 65+.			
			Unidentifiable	Indicates that the individuals' age and/or gender is not identifiable			
			Female	Female	(Ohta and		

			Male	Male	Ohashi 1985; Goltz et al. 1992; Bourque et al. 1993; Mahue-Giangreco et al. 2001; Peek-Asa et al. 2003; Ramirez et al. 2005b; Kanter 2010)		there are three broad categories can be used. If the age of the individual can be determined, the higher resolution categories can be applied. The boundaries between the age descriptors cannot be defined exactly so use physical indications, such as height and build to differentiate the ages.
Keyword Group *(Catergory)*		**Keyword** *(Code)*		**Description**	**Reference**	**Relevance**	**Justification**
		Low resolution	**High resolution**				
Contextual data (non-time dependent)	**Individual**		Mobility aid	Indicates the individual has a mobility aid		Did the individual have a mobility impairment that potentially affected their response actions and time?	Mental and Physical disability were also considered as an influence of the individual’s ability to respond to the event however there is no knowledge of prior health status and determining the nature and level of disability was too uncertain. However, if it is observable that the individual has a mobility aid it can be coded for e.g. wheelchair, walking frame, guide dog this is to be included.

Keyword Group (*Category*)		Keyword (*Code*) Low Resolution	Keyword (*Code*) High Resolution	Description	Reference	Relevance	Justification
Contextual data (non-time depended)	**Pre-event**	Performing a task	Active	Indicates if the person is was active, performing a task or sleeping before the earthquake shaking began.		How does the behaviour of the individual change once the earthquake shaking begins?	Any activity that the individual is involved in before the event will be coded as 'performing a task'. This is to differentiate if an activity/action was continued or if an action was triggered by the earthquake. For example a person may have been driving before the earthquake and continued driving once the shaking began. Because their actions did not change during the earthquake, this will be coded for as 'Continued performing a task'.
			Sleeping				
			Alone	Indicates the individual is alone for the entire duration of the video. There is no visual and/or oral evidence of other people.		Do people behave differently when alone or with others?	To understand how the presence of others influence behaviour, code if the person is alone, with another person/people, or if there is a child (secondary school age and younger) present. There is no knowledge of prior relationship or responsibility to other people (e.g. mother, husband, friend etc.) so cannot be coded for.
			With others	Indicates the person is with another person/ people at any time of the video. Needs visual and/or oral evidence of other people.			

Keyword Group *(Category)*		Keyword *(Code)*		Description	Reference	Relevance	Justification
		Low resolution	**High resolution**				
Contextual data (non-time dependent)	**Pre-event**		With child/ren	Indicates the person is with a child(ren) at any time of the video. Needs to have visual and/or oral evidence	(Ohta and Ohashi 1985; Goltz et al. 1992; Bourque et al. 1993)	Will people protect children before themselves?	This code has been included to indicate if the there was a child present, to understand if this influences the individuals' response.
			Indoor	Indoor footage		Do people behave differently in different locations/ environments?	Location is coded for as either inside, outside and in the context of: home, workplace or public. Further breakdown too uncertain e.g. building type, floor level. It was also considered to code if the person was in a familiar environment such as workplace or home however there was also too much uncertain e.g. an individual may be in a home environment but whether it is the individuals home is not clear.
			Outdoor	Outdoor footage			
			Home	Home environment			
			Workplace	For example, office, school			
			Public	For example, shopping complex, street			

Keyword Group *(Category)*		Keyword *(Code)*	Description	Reference	Relevance	Justification
Trigger	**During event**	Environmental Trigger	Trigger to respond to the earthquake is environmental, e.g. difficulty standing or performing previous tasks. With audio data the individual may hear the earthquake	(Lindell and Perry 2012)	What is the most common cue that triggers awareness? Are people aware they are in danger, or do they follow the response and actions of others?	This code is to be applied when the person first perceives the event e.g. If the person stops current activity and looks around the room, code as 'environmental cue'. A 'social cue' can only be considered if there are other people present e.g. if the individual only takes action once another person in the frame has responded
		Social Trigger	The individual responds because of the actions of others. Needs to be evidence that other people/person takes action and the individual then responds			
Response Actions		Looks around	Indicates the person is looking around and scanning. Only applicable if there is visual evidence of turning their head		What is the initial response behaviour that people engage in, including affiliation behaviour (seeking the proximity of others) and movement type?	These are basic level actions that can be identified in the video e.g. 'Follows', 'evacuates' and the type of movement e.g. 'runs', 'walks'.
		Ambulate	Indicates moving from place to place			
		Sits	Indicates the person is sitting			
		Stands	Indicates the person is standing			
		Runs	Indicates the person is running	(Alexander 1990)		
		Walks	Indicates the person is walking			

Keyword Group *(Category)*		Keyword *(Code)*	Description	Reference	Relevance	Justification
Response Actions	**During event**	Jumps	Indicates the person jumps over an object		What is the initial response behaviour that people engage in, including affiliation behaviour (seeking the proximity of others) and movement type?	These are basic level actions that can be identified in the video e.g. 'Follows', 'evacuates' and the manner of movement e.g. 'runs', 'walks'.
		Uses phone	Indicates the person is using a phone			
		Stops driving	Indicates the person stopped driving	(Goltz et al. 1992)		
		Pulls over to the side of the road	Indicates the person pulled over to the side of the road	(Goltz et al. 1992)		
		Evacuates	Indicates the person leaves the room/building. No evidence of return	(Ohta and Ohashi 1985; Alexander 1990; Goltz et al. 1992; Bourque et al. 1993; Rosoff et al. 2011; Prati et al. 2012; Prati et al. 2013)		

Keyword Group *(Category)*		Keyword *(Code)*	Description	Reference	Relevance	Justification
Response Actions	**During event**	Protects contents	Indicates the person tried to prevent/succeeded in preventing an object from falling/overturning	(Archea and Kobayashi 1984; Goltz et al. 1992; Bourque et al. 1993; Koyama et al. 2011; Prati et al. 2012)		Studies have also reported that people will try to protect contents from falling/overturning. The descriptions that have been previously used to describe this action were either unclear, 'Against Overturning' (Koyama et al. 2011) or too specific, 'Caught objects' (Goltz et al. 1992). This code was developed to describe any instance where the person moves to any object, e.g. television, chair and describes any form of protection e.g. holding, catching etc.
		Continues performing a task	Indicates the person continues the activity/task they were performing before the earthquake	(Ohta and Ohashi 1985)		A person may continue the task or activity they were performing before the earthquake shaking began. This code has been included to distinguish what actions were triggered by the earthquake event.

Keyword Group *(Category)*		Keyword *(Code)*	Description	Reference	Relevance	Justification
Response Actions	**During event**	Moves toward another person/crowd	Indicates the person moves toward another person/ crowd	(Goltz et al. 1992)		Initially 'moves toward' and 'moves away' were the only codes to represent affiliation behaviour such as forming a group. However there were some instances where a person would follow or shadow the actions of another person e.g. They moved toward another person and then walked out of the frame, moving with, or after the person. This is coded for as 'follows'.
		Moves away from another person /crowd	Indicates the person moves away/disconnects from a person/crowd			
		Follows	Indicates the person moves with or follows a person/crowd			
		Uncontrolled Response	Indicates the person could not do anything because of strong earthquake motion	(Koyama et al. 2011)	Are actions prevented or slowed?? Was the individual able to respond to the shaking	These codes represent that the individual could not respond to the event because of factors beyond their control. This provides insight as to why an individual may not have performed a self-protective action.
		Falls	Indicates the person falls			
		Hit	Indicates the person is hit by falling object			
		Immobilized	Indicates the person is not moving, or has frozen, however there is no evidence of cause of injury			

Keyword Group *(Category)*		Keyword *(Code)*		Description	Reference	Relevance	Justification
		Low resolution	**High resolution**				
Injury	**During event**	Injured	Injury 0	• **0-** injury status unclear. E.g. the person is struck by a falling object and they are no longer in the view of the camera, therefore it is unclear if they have been injured		Was the individual injured?	Injury severity is not differentiated because the prior health status is not known and therefore relatedness to the earthquake or the causative factor of the injury cannot be coded with certainty. Furthermore to classify 'minor' injuries sustained is misleading as it may have prevented the individual from greater injury/death (Petal 2011). If the person enters the frame and is injured, for example limping, or if it is too difficult to determine the status of the injury because of poor video quality or people blocking the view, use the low resolution 'Injured' code. Use the higher resolution codes to differentiate the level of impact of injury on the person.
			Injury 1	• **1-** No evidence of impairment e.g. the person is struck by the falling object, and continues walking therefore the impact is unclear			
			Injury 2	• **2-** Evidence of impairment e.g. the person is struck by a falling object and has visual/oral evidence of injury.			
			Injury 3	• **3-** Incapacitated e.g. the person is struck by a falling object and there is no movement (unconscious/dead)			

Keyword Group *(Category)*		Keyword *(Code)*	Description	Reference	Relevance	Justification
Self- protective actions	**During event**	Bends Forward	Indicates the person bends forward		Do people attempt to protect themselves? Do people Drop, Cover and Hold?	The protective actions are broken down because a person may attempt some but not all actions or may not be successful in completing an action e.g. A person may cover themselves under a table but does not wait for the earthquake shaking to stop before they move again. Or the earthquake shaking may be too strong, preventing the person from moving so they may hold an object to balance themselves. The 'Drops' code is applied if the person drops to the ground/crouches and the 'Covered' code is applied only if the person successfully moves under a doorframe or table.
		Braces Head	Indicates the person braces their head with their hands			
		Drops	Indicates the person drops their body to the ground in a controlled manner			
		Attempts to move under furniture	Indicates the person moves to furniture e.g. table or desk	(Archea and Kobayashi 1984; Goltz et al. 1992; Bourque et al. 1993; Rosoff et al. 2011; Prati et al. 2012; Prati et al. 2013)		
		Attempts to move under doorframe	Indicates the person moves to a doorframe			
		Covered	Indicates the person has successfully covered themselves from falling objects/fittings under furniture/doorframe			
		Holds	Indicates the person uses an object/ furniture or person to balance			

Keyword Group (Category)		Keyword (Code)	Description	Reference	Relevance	Justification
Protective actions towards others	**During event**	Provides assistance	Physically helps/ comforts another person. E.g. helps another person walk/stand.	(Goltz et al. 1992; Prati et al. 2012)	Do people protect others before themselves?	The actions that a person takes may be for the care/ protection of other people present in the frame or for other people close to the person but not in the frame, e.g. in a different room of a house so calls out. The actions of some may also be as a result of being instructed or directed. Protection to other people could be in the form of physical or communicated actions, e.g. physically covering another person, or telling someone to take cover.
		Receives assistance	Physically receives help/comfort from another person e.g. is helped to walk.			
		Gives instruction/s	Indicates the person gives an instruction of what to do. Only applicable with clear audio data			
		Listens to instruction/s	Indicates the person acts as instructed. Only applicable with clear audio			
		Oral communication	Indicates there is oral evidence the person is communicating.			Include all audio data where the person is instructing or inquiring. The audio data may not always be clear or included in the video so will be coded for if there is any visual evidence of communicating e.g. body positioning, facial expressions, mouth movement etc. A person may also communicate not to give instructions but to seek information e.g. asking about the event or wellbeing of another person which will be coded for as information seeking.
		Visual communication	Indicates there is visual evidence the person is communicating			
		Information Seeking	Oral evidence that the person is information seeking. Only applicable with clear audio data			

Keyword Group *(Category)*		Keyword *(Code)*	Description	Reference	Relevance	Justification
Response Actions	**Post-event**	Looks around	Indicates the person is looking around and scanning. Only applicable if there is visual evidence of turning their head		What is the initial response behaviour that people engage in, including affiliation behaviour (seeking the proximity of others) and movement type?	[2]. There was only evidence of a person turning off utilities once the shaking had stopped so it is only included in this keyword group
		Ambulate	Indicates moving from place to place			
		Sits	Indicates the person is sitting			
		Stands	Indicates the person is standing			
		Runs	Indicates the person is running	(Alexander 1990)		
		Walks	Indicates the person is walking			
		Jumps	Indicates the person jumps over an object			
		Stops driving	Indicates the person stopped driving	(Goltz et al. 1992)		
		Pulls over to the side of the road	Indicates the person pulled over to the side of the road			
		Evacuates	Indicates the person leaves the room/building. No evidence of return	(Ohta and Ohashi 1985; Alexander 1990; Goltz et al. 1992; Bourque et al. 1993; Rosoff et al. 2011; Prati et al. 2012; Prati et al. 2013)		

[2] Apart from 'turns off utilities' there is no new keywords in the Post-event keyword Group. See all justifications in the During event keyword group.

Keyword Group *(Category)*		Keyword *(Code)*	Description	Reference	Relevance	Justification
Response Actions	**Post-event**	Uses phone	Indicates the person is using a phone			
		Protects contents	Indicates the person tried to prevent/succeeded in preventing an object from falling/overturning	(Archea and Kobayashi 1984; Goltz et al. 1992; Bourque et al. 1993; Koyama et al. 2011; Prati et al. 2012)		
		Continues performing a task	Indicates the person continues the activity/task they were performing before the earthquake	(Ohta and Ohashi 1985)		
		Moves toward another person/crowd	Indicates the person moves toward another person/ crowd	(Goltz et al. 1992)		
		Moves away from another person /crowd	Indicates the person moves away/disconnects from a person/crowd			
		Follows	Indicates the person moves with or follows a person/crowd			
		Uncontrolled Response	Indicates the person could not do anything because of strong earthquake motion	(Koyama et al. 2011)		
		Falls	Indicates the person falls			
		Hit	Indicates the person is hit by falling object			
		Immobilised	Indicates the person is not moving, or has frozen, however there is no evidence of cause of injury			

Keyword Group (Category)		Keyword (Code)		Description	Reference	Relevance	Justification
		Low resolution	High resolution				
Injury	**Post-event**	Injured	Injury 0	• **0-** injury status unclear. E.g. the person is struck by a falling object and they are no longer in the view of the camera, therefore it is unclear if they have been injured		Was the individual injured? What impact did the injury have on the individual?	
			Injury 1	• **1-** No evidence of impairment e.g. the person is struck by the falling object, and continues walking therefore the impact is unclear			
			Injury 2	• **2-** Evidence of impairment e.g. the person is struck by a falling object and has visual/oral evidence of injury.			
			Injury 3	• **3-** Incapacitated e.g. the person is struck by a falling object and there is no movement (unconscious/dead)			

Keyword Group *(Category)*		Keyword *(Code)*	Description	Reference	Relevance	Justification
Self- protective actions	**Post-event**	Bends Forward	Indicates the person bends forward		Do people attempt to protect themselves? Do people “Drop, Cover and Hold”?	
		Braces Head	Indicates the person braces their head with their hands			
		Drops	Indicates the person drops their body to the ground in a controlled manner			
		Attempts to move under furniture	Indicates the person moves to furniture e.g. table or desk	(Archea and Kobayashi 1984; Goltz et al. 1992; Bourque et al. 1993; Rosoff et al. 2011; Prati et al. 2012; Prati et al. 2013)		
		Attempts to move under doorframe	Indicates the person moves to a doorframe			
		Covered	Indicates the person has successfully covered themselves from falling objects/fittings under furniture/doorframe			
		Holds	Indicates the person uses an object/ furniture or person to balance			

Keyword Group *(Category)*		Keyword *(Code)*	Description	Reference	Relevance	Justification
Protective actions towards others	**Post-event**	Provides assistance	Physically helps/ comforts another person. e.g. helps another person walk/stand, holds another person	(Goltz et al. 1992; Prati et al. 2012)	Do people protect others before themselves?	
		Receives assistance	Physically receives help/comfort from another person e.g. is helped to walk/ stand, is held by another person			
		Gives instruction/s	Indicates the person gives an instruction of what to do. Only applicable with clear audio data			
		Listens to instruction/s	Indicates the person acts as instructed. Only applicable with clear audio			
		Oral communication	Indicates there is oral evidence the person is communicating.			
		Visual communication	Indicates there is visual evidence the person is communicating			
		Information Seeking	Oral evidence that the person is information seeking. Only applicable with clear audio data			

Keyword Group *(Category)*		Keyword *(Code)*	Description	Reference	Relevance	Justification
Observation of Individual	**Visual**	Not observable	Indicates the person is not in the frame or is cut off by the camera angle/ another person		To code for those people who enter and exit the camera frame.	This category had to be included to represent where there is no observable evidence of actions. There was a separate code for ‘exits the frame’ that was intended to represent a person that was no longer in view of the camera; however it was collapsed into the ‘not observable’ code because it was considered too similar to be a separate code.
		Re-enters frame	Indicates the person re-enters the frame or the person/ object blocking them has moved			
		Enters frame	Indicates the person enters the frame during or after earthquake shaking.			

Keyword Group *(Category)*		Keyword *(Code)*	Description	Reference	Relevance	Justification
Earthquake attributes	**Shaking Intensity**	MM 1	Unnoticeable. Barely sensed by only a few people	(Dowrick et al. 2008)	How does shaking intensity influence behaviour and response actions	It was decided to include shaking intensity to explore any relationship between actions and intensity and to provide reference for other codes e.g. an ‘environmental cue’ to the shaking may not be feasible if the shaking intensity is unnoticeable (MM1) to Light (MM4). Shaking intensity was measured using The New Zealand Modified Mercalli Intensity scale as an observable indicator of the earthquakes effects on people and the environment
		MM 2	Unnoticeable. Felt by persons at rest, on upper floors or favorably placed			
		MM 3	Weak. Felt indoors; hanging objects may swing			
		MM 4	Light. Generally noticed indoors, but not outside			
		MM 5	Moderate. Generally felt outside and by almost everyone indoors. Small unstable objects are displaced or upset. Some glassware and crockery may be broken. Hanging pictures knock against the wall. Open doors may swing			
		MM 6	Strong. Walking steadily is difficult. Objects fall from shelves, pictures fall from walls. Some furniture moved on small floors. Very unstable furniture overturned			
		MM 7	Severe and damaging. General alarm. People experience difficulty standing. Furniture and appliances are shifted. Substantial damage to fragile contents of buildings			

Keyword Group *(Category)*		Keyword *(Code)*	Description	Reference	Relevance	Justification
Earthquake attributes	**Shaking Intensity**	MM 8	Severe and heavily damaging. Alarm may approach panic. Steering of motorcars is greatly affected. Some damage to buildings		How does shaking intensity influence behaviour and response actions	
		MM 9	Destructive. Some buildings are damaged and some weak buildings are destroyed			
		MM 10	Very Destructive. Many buildings are damaged and many weak buildings are destroyed			
		MM 11	Devastating. Most buildings are damaged and many weak buildings destroyed			
		MM 12	Completely Devastating. All buildings are damaged and most buildings are destroyed			

Appendix C- Video analysis in Transana

The process of analysis used in this research is explained to instruct a coder of the steps necessary to compete all file management, transcription and coding in Transana. This will ensure that any cross-analysis of future work has compatible databases. Transana can be downloaded from the Transana webpage. If another qualitative analysis program has been selected, it is recommended that the method of data management follows these instructions as closely as possible. Regardless of the program selected, the unit of analysis has to be the individual person. The instructions are followed with a presentation of a worked example of a video.

C.1. File Management

The data window is where you organize your data and where you can access files to work with (see Figure C.1)

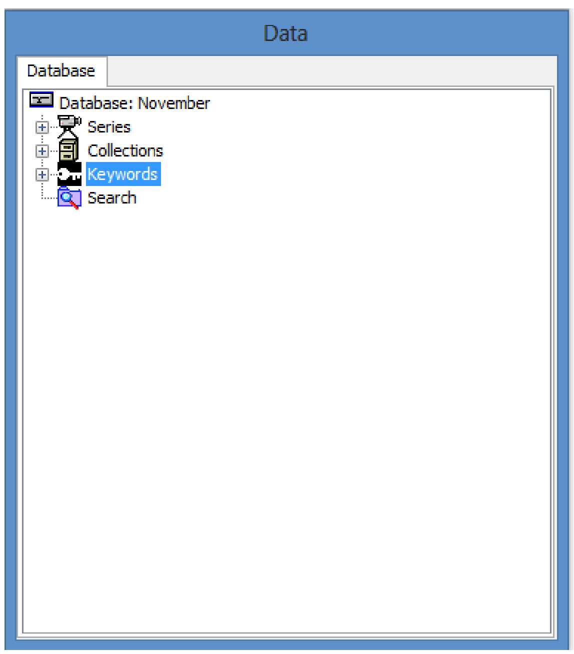


Figure C.1: Screen shot of the data window where all data is managed and accessed.

- Set up the database where all media data will be stored.
- Add a series before importing any video files. Right click the series icon in the data window and select add series. The series identification will depend on how you are

analysing the footage. If analyzing footage from one event with multiple sources such as, hospital, airport, supermarket, etc., use the month the earthquake footage was from. For example, series identification would be February and will contain all footage collected from February. If analysing data from one source from multiple events, name the series according to the source. For example, series identification would be Christchurch City Public Hospital and will contain all footage collected from the Christchurch City Public Hospital.

- Import all the video files relating to the series you have created. In Transana a video file is referred to as an episode. Right click on the series and select add episode. The episode identification should be:
  Date_Earthquake_Video number
  For example, 220211_CANT_1 (22 February 2011_CANT_Video1)
- Each episode can contain multiple transcripts. A transcript will be created for every individual who enters and exits the frame throughout the entire duration of the video file.
- Watch each video and record the number of people who can be seen. To create a transcript for a person, right click on the episode icon in the data window and select add transcript. The transcript identification will be consistent with the episode identification e.g.
- Date_Earthquake_Video number_Person number e.g. 220211_CANT_1_1 (22 February 2011_CANT_Video1_Person1)
- Create a collection for every transcript you have created. Right click Collection, and select add collection. The collection identification should be the same as the transcript identification e.g.
  Date_Earthquake_Video number_Person number e.g. 220211_CANT_1_1 (22 February 2011_CANT_Video1_Person1)

The following figure shows a screen shot from the data window that was used in this research. Once every video file has been imported into Transana and the set up for file management is complete, the coder can begin transcribing the footage.

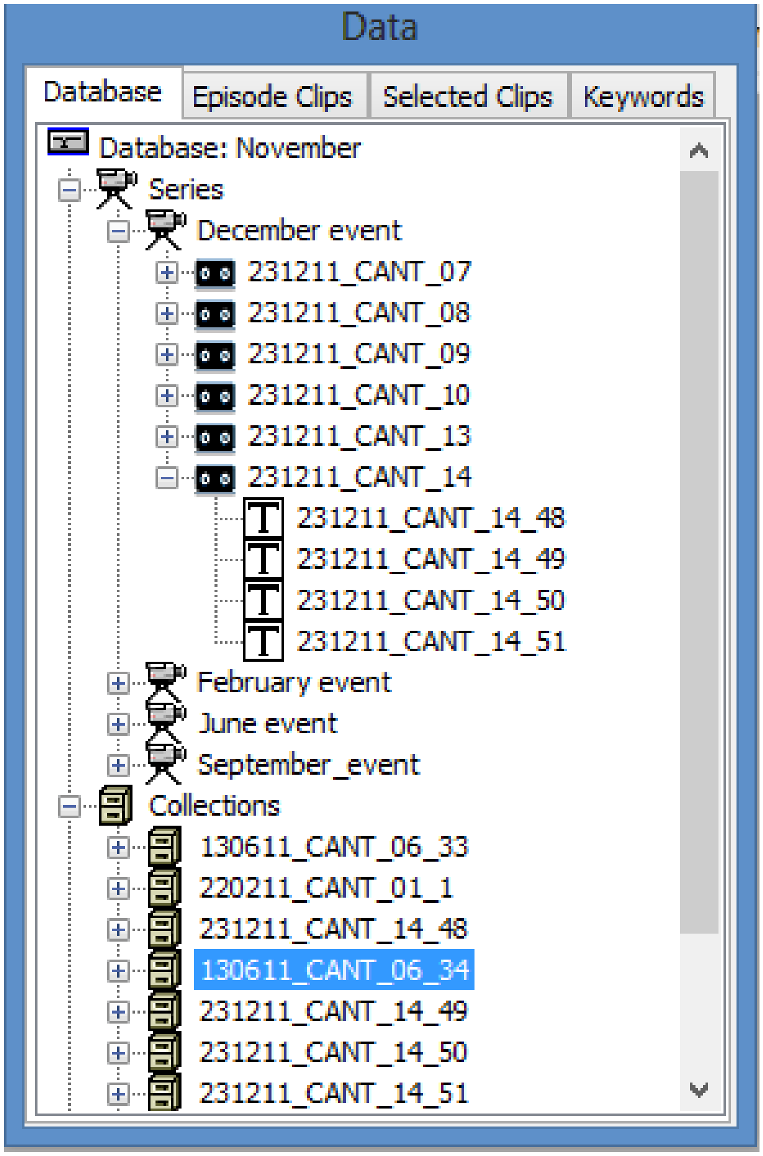


Figure C.2: Screen shot of the data window in Transana with: series, episodes, transcripts and collections added

C.2. Transcribing

The transcripts will represent the point at which earthquake shaking is observed, and the point at which it stops; the physical and gestural actions of the individual; and audio data if it is available.

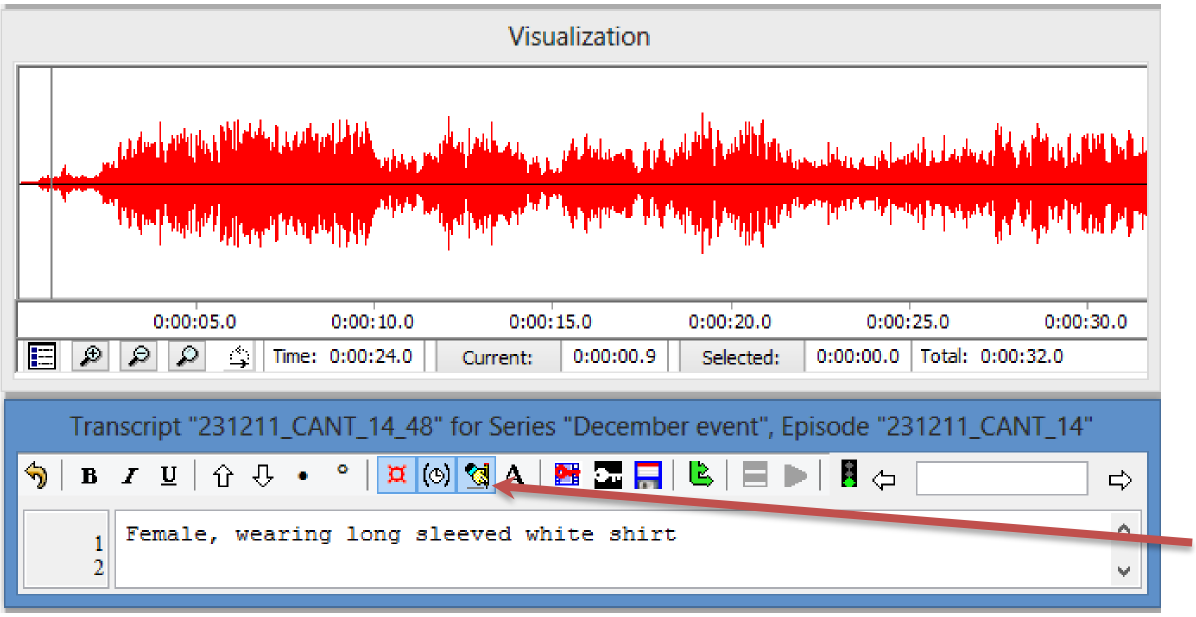
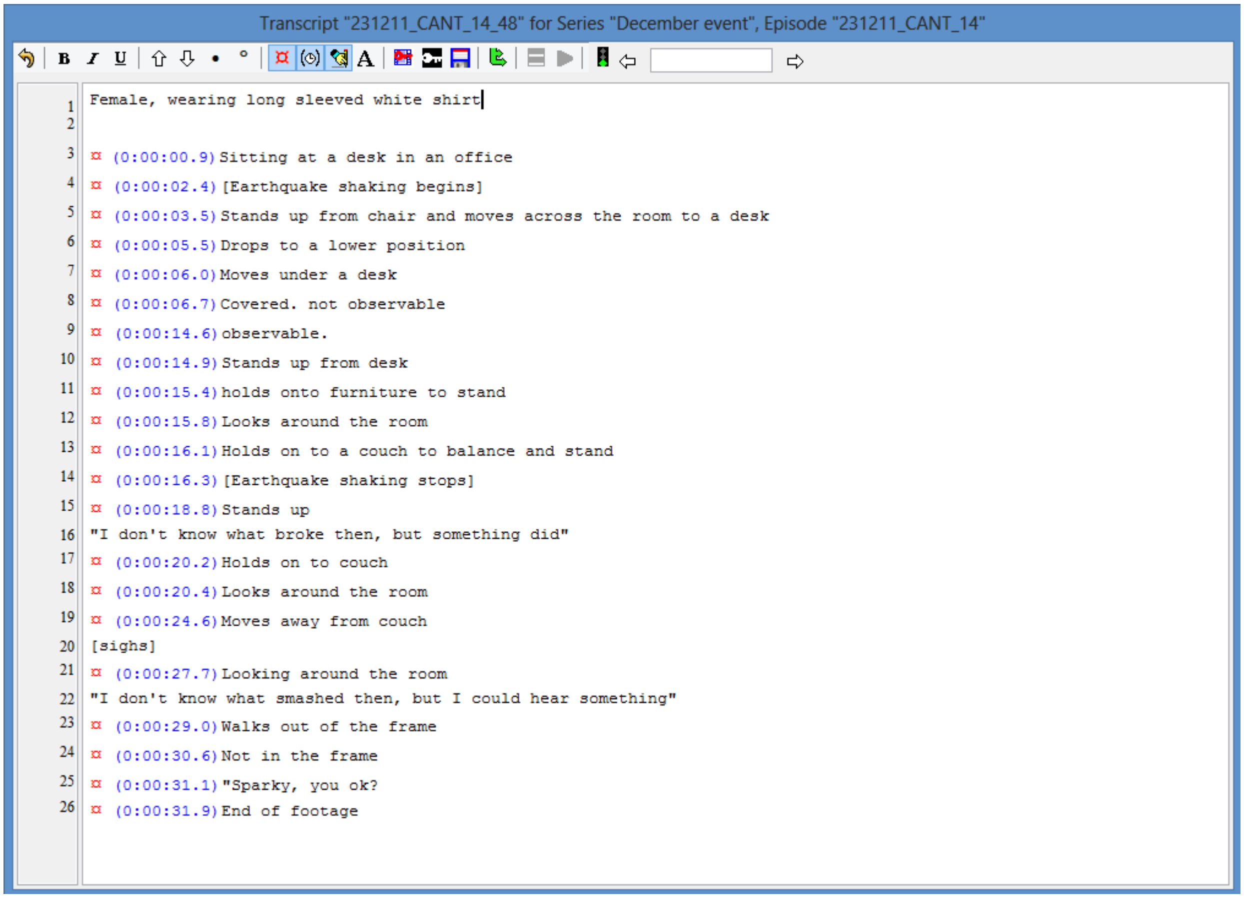


Figure C.3: Screen shot showing the visualization window in Transana and the tool bar of the transcript window.

To check that the transcript is in edit mode, click on the edit tool (see Figure C.3)

- Transana will automatically load the video file and the synchronized transcript.
- Play the video and record a description of the individual being observed, for example, adult male wearing blue shirt to the left. This will help another coder identify the person in the video (See Figure C.3).
- Insert a time stamp (CRTL,T) and write the activity and simultaneous activity of the person. The visualisation window above the transcript window shows the time of the video and should be used to insert the time stamp as accurately as possible (see Figure C.3)
- Add a new line and insert another time stamp when the actions change. Repeat this step for every change and modification to behaviour for the duration of the video.
- Insert a time stamp when the earthquake shaking begins and stops.
- Repeat the transcription for every individual in the data set.

The format and content of this transcript in Figure C.4 should be used as an example.


Transcript "231211_CANT_14_48" for Series "December event", Episode "231211_CANT_14"

Female, wearing long sleeved white shirt

¤ (0:00:00.9) Sitting at a desk in an office
¤ (0:00:02.4) [Earthquake shaking begins]
¤ (0:00:03.5) Stands up from chair and moves across the room to a desk
¤ (0:00:05.5) Drops to a lower position
¤ (0:00:06.0) Moves under a desk
¤ (0:00:06.7) Covered. not observable
¤ (0:00:14.6) observable.
¤ (0:00:14.9) Stands up from desk
¤ (0:00:15.4) holds onto furniture to stand
¤ (0:00:15.8) Looks around the room
¤ (0:00:16.1) Holds on to a couch to balance and stand
¤ (0:00:16.3) [Earthquake shaking stops]
¤ (0:00:18.8) Stands up
"I don't know what broke then, but something did"
¤ (0:00:20.2) Holds on to couch
¤ (0:00:20.4) Looks around the room
¤ (0:00:24.6) Moves away from couch
[sighs]
¤ (0:00:27.7) Looking around the room
"I don't know what smashed then, but I could hear something"
¤ (0:00:29.0) Walks out of the frame
¤ (0:00:30.6) Not in the frame
¤ (0:00:31.1) "Sparky, you ok?
¤ (0:00:31.9) End of footage

Figure C.4: Screen shot showing an example of a transcript.

C.3. Coding

To begin the coding process, add in the keyword group and keywords (see Appendix B for the final coding scheme). The keyword definition in Transana should be the same as the descriptions provided in the coding scheme (see Figure C.5).

- To add the keyword groups and keywords, right click on the keywords icon in the data window and select keyword management.

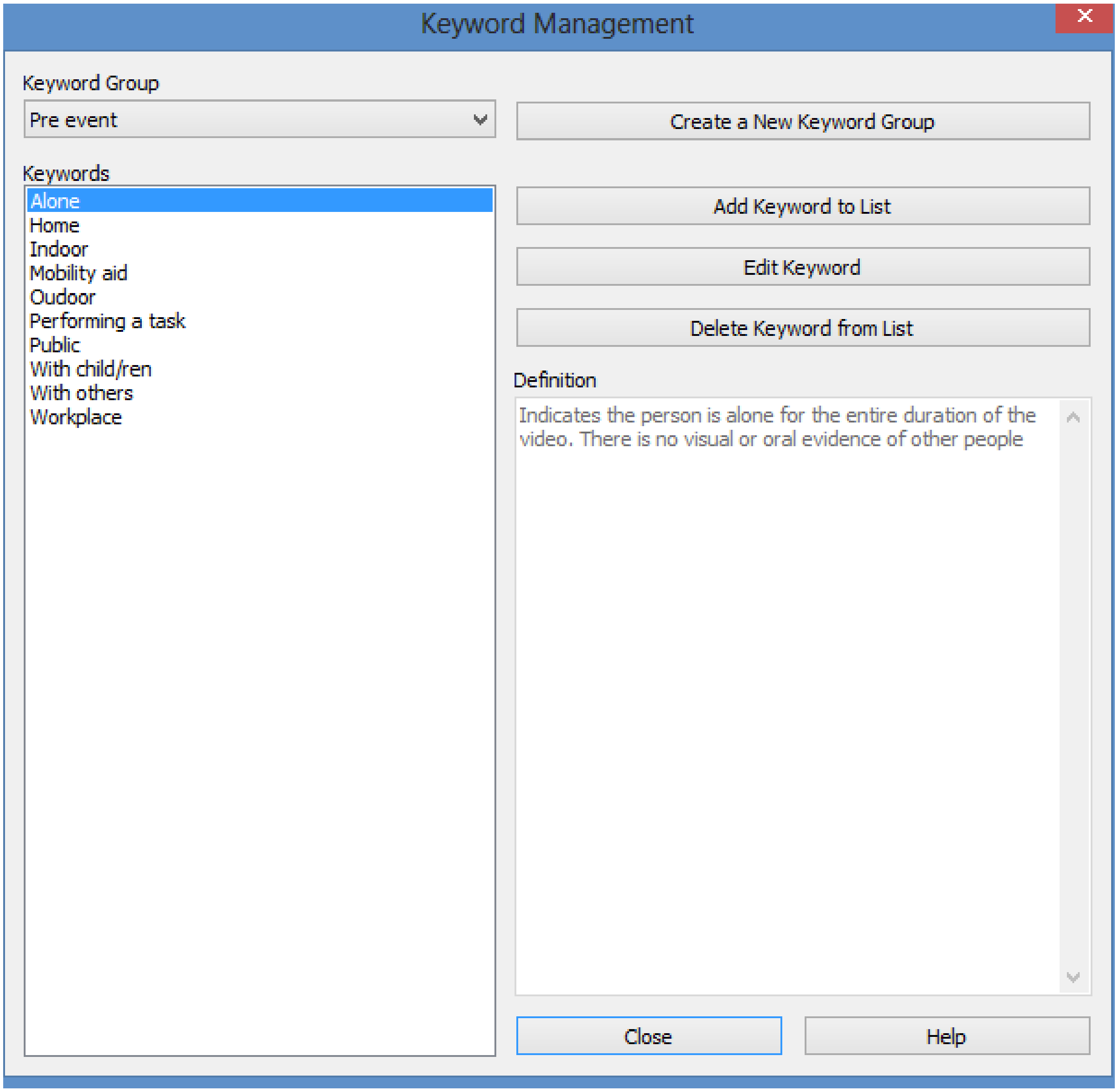


Figure C.5: Screen shot of the Keyword management tool in Transana

- All transcripts are to be coded individually. To apply codes to a transcript, open the transcript. The video will automatically open in the video window.
- Highlight the text and timestamp and drag to the related collection. For example if you are working with Transcript:231211_CANT_14_48, the highlighted text should be dragged to Collection:231211_CANT_14_48.

- Transana will automatically create a clip (see Figure C.6). The clip should be numbered as they are created. The total number of clips in a collection will depend on the activity of the individual.
- Apply the appropriate keyword group and keywords to the clip, using the text and the video playback as a guide (see Figure C.6).

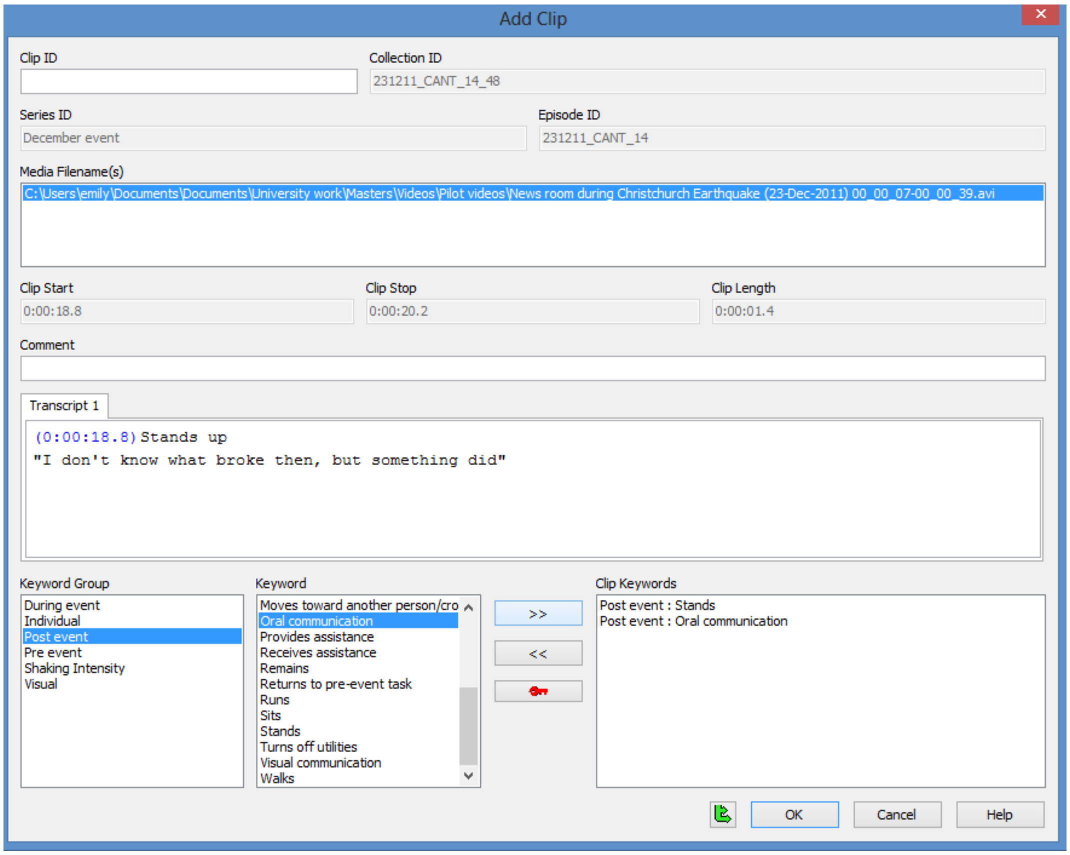


Figure C.6: Screen shot showing keyword application to selected transcript.

- Repeat this step for every action that the individual engages in for the duration of the video.
- Code all transcripts.
- To display the coded data from Transana, right click on the collection and select keyword collection map. Transana will display all codes that have been applied to that collection as a keyword map (see Figure C.7).

- This represents the start and end points of the codes applied along a horizontal timeline representing the duration of the video in seconds. The vertical axes show the keyword group and keyword that have been applied.

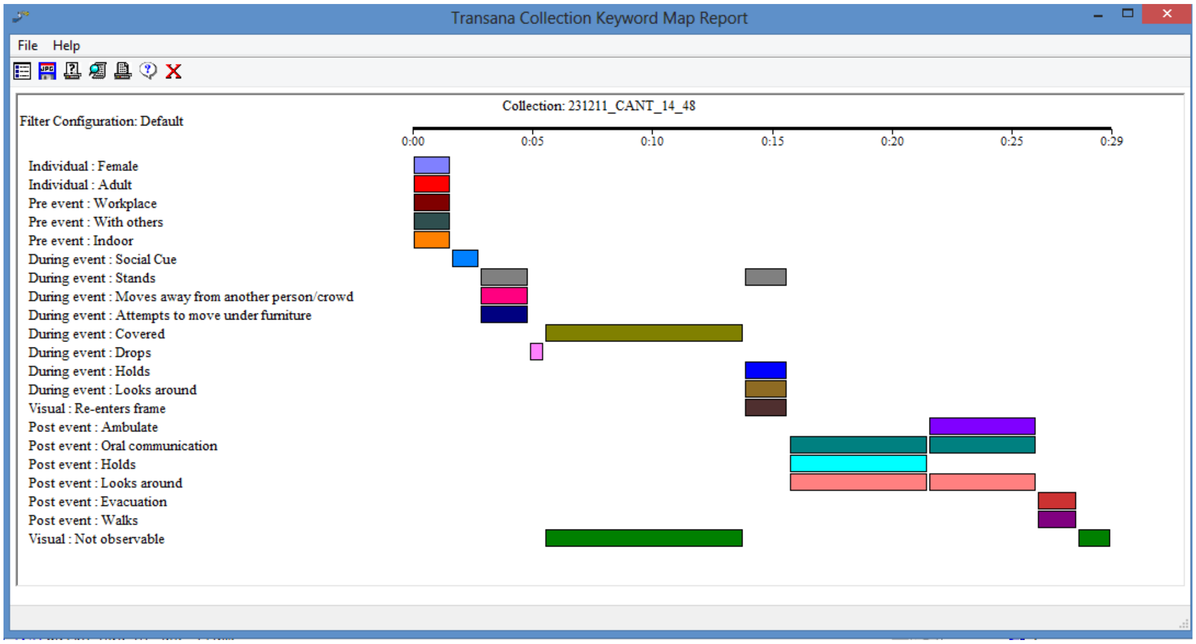


Figure C.7: Screen shot of a keyword map

- The keyword groups are arranged in alphabetical order by default. The codes can be rearranged to show the sequence of actions. Click on the filter icon and select the keyword tab. Select a keyword and use the arrows to move the codes up and down in the order they occurred (see Figure C.8).

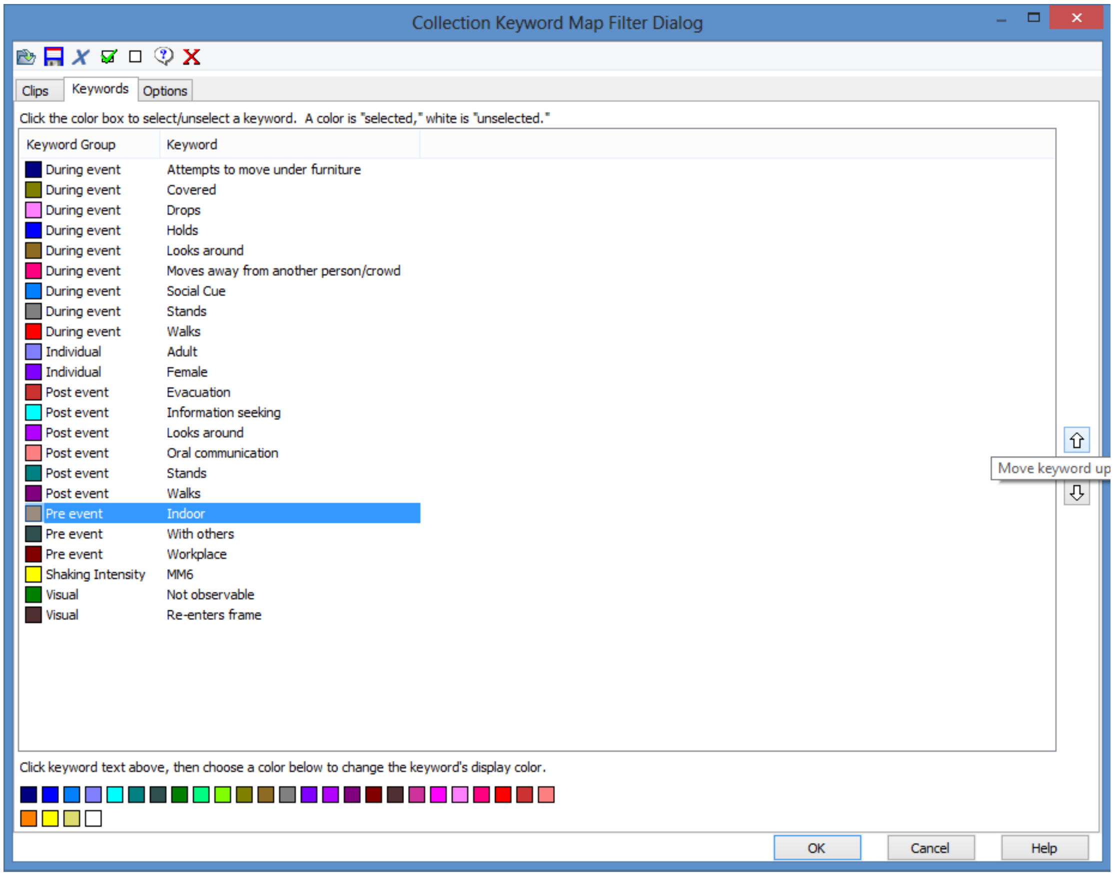


Figure C.8:Screen shot of the filter dialog tool that can be used to order the keywords

Observation of video data

The following figure provides screen shots from an example video (The Telegraph 2011) to show how the video data should be objectively transcribed

Figure C.9: Observation in Transana

News Room during 23 December 2011 earthquake

Time 0:00:00.9

Time 0:00:03.2

Time 0:00:04.4

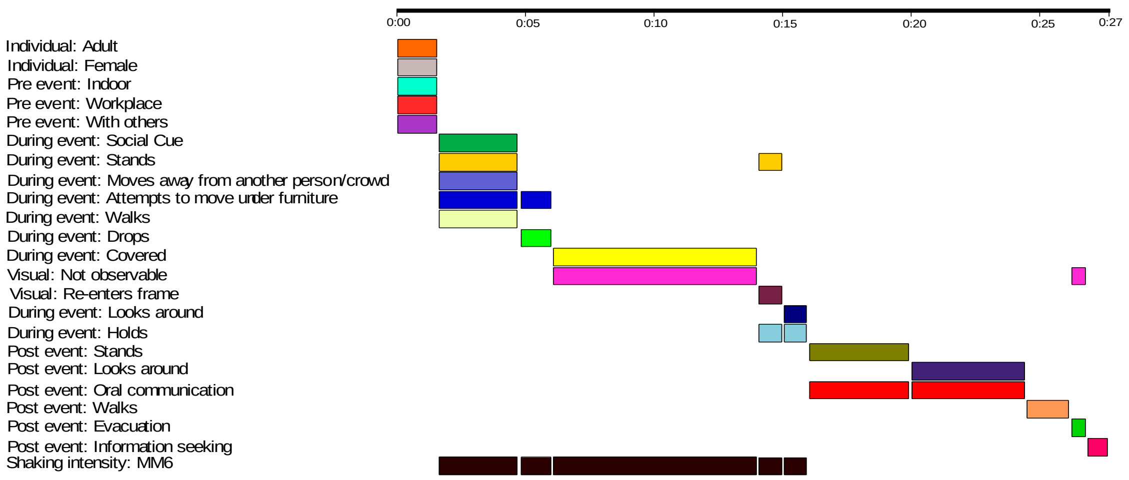
Time 0:00:05.3

Transcript:231211_CANT_14_48

Female, wearing long sleeved white shirt

¤ (0:00:00.9) Sitting at a desk in an office
¤ (0:00:02.4) [Earthquake shaking begins]
¤ (0:00:03.5) Stands up from chair and moves across the room to a desk
¤ (0:00:05.5) Drops to a lower position
¤ (0:00:06.0) Moves under a desk
¤ (0:00:06.7) Covered. not observable
¤ (0:00:14.6) observable.
¤ (0:00:14.9) Stands up from desk
¤ (0:00:15.4) holds onto furniture to stand
¤ (0:00:15.8) Looks around the room
¤ (0:00:16.1) Holds on to a couch to balance and stand
¤ (0:00:16.3) [Earthquake shaking stops]
¤ (0:00:18.8) Stands up
"I don't know what broke then, but something did"
¤ (0:00:20.2) Holds on to couch
¤ (0:00:20.4) Looks around the room
¤ (0:00:24.6) Moves away from couch
[sighs]
¤ (0:00:27.7) Looking around the room
"I don't know what smashed then, but I could hear something"
¤ (0:00:29.0) Walks out of the frame
¤ (0:00:30.6) Not in the frame
¤ (0:00:31.1) "Sparky, you ok?
¤ (0:00:31.9) End of footage

Collection Keyword Map: 231211_CANT_14_48



Time 0:00:06.8

Time 0:00:16.5

Time 0:00:27.2

Time 0:00:30.8

Appendix D- Modified Mercalli Intensity Scale

Modified Mercalli Itensity Sclae NZ 2007 (Dowrick et al. 2008)

Items marked * in the scale are defined in the notes following. Revisions in this version of the scale are shown in italics.

MM1 *People*

Not felt except by a very few people under exceptionally favourable circumstances.

MM2 *People*

Felt by persons at rest, on upper floors or favourably placed.

MM3 *People*

Felt indoors; hanging objects may swing, vibration similar to passing of light trucks, duration may be estimated, may not be recognised as an earthquake.

Fittings

Liquids in large open containers may be disturbed (sometimes considerably) in large magnitude (long duration) earthquakes.

Pendulum clocks may stop, start, or change rate (H).*

MM4 *People*

Generally noticed indoors but not outside. Light sleepers may be awakened. Vibration may be likened to the passing of heavy traffic, or to the jolt of a heavy object falling or striking the building.

Fittings

Doors and windows rattle. Glassware and crockery rattle. Liquids in open vessels may be slightly disturbed *in small to mediumsized earthquakes*. Standing motorcars may rock.

Structures

Walls and frames of buildings, and partitions and suspended ceilings in commercial buildings, may be heard to creak.

MM5 *People*

Generally felt outside, and by almost everyone indoors. Most sleepers awakened. A few people alarmed.

Fittings

Small unstable objects are displaced or upset. Some glassware and crockery may be broken. Hanging pictures knock against the wall. Open doors may swing. Cupboard doors secured by magnetic catches may open.

Structures

Some windows Type I* cracked. A few earthenware toilet fixtures cracked, *in timber buildings with inadequately braced piles.*

Environment

Loose boulders may occasionally be dislodged from steep slopes.

MM6 *People*

Felt by all. People and animals alarmed. Many run outside.* Difficulty experienced in walking steadily.

Fittings

Objects fall from shelves. Pictures fall from walls (H*). Some furniture moved on smooth floors, some unsecured free-standing fireplaces moved. Glassware and crockery broken. Very unstable furniture overturned. Small church and school bells ring (H*). Appliances move on bench or table tops. Filing cabinets or "easy glide" drawers may open (or shut).

Structures

Slight damage to Buildings Type I*. Some stucco or cement plaster falls. Windows Type I* broken. Damage to a few weak domestic chimneys, some may fall.

Environment

Trees and bushes shake, or are heard to rustle. Loose material may be dislodged from sloping ground, e.g. existing slides, talus *and scree* slopes. A few very small (≤103 m3) soil and regolith slides and rock falls from steep banks and cuts. A few minor cases of liquefaction (sand boil) in highly susceptible alluvial and estuarine deposits.

MM7 *People*

General alarm. Difficulty experienced in standing. Noticed by motorcar drivers who may stop.

Fittings

Large bells ring. Furniture moves on smooth floors, may move on carpeted floors. Substantial damage to fragile* contents of buildings.

Structures

Unreinforced stone and brick walls cracked. Buildings Type I cracked some with minor masonry falls. A few instances of damage to Buildings Type II. Unbraced parapets, unbraced brick gables, and architectural ornaments fall. Roofing tiles, especially ridge tiles may be dislodged. Many unreinforced domestic chimneys damaged, often falling from roof-line. Water tanks Type I* burst. A few instances of damage to brick veneers and plaster or cement-based linings. Unrestrained water cylinders (Water Tanks Type II*) may move and leak. Some windows Type II* cracked. Suspended ceilings damaged.

Environment

Water made turbid by stirred up mud. Small slides such as falls of sand and gravel banks, and small rock-falls from steep slopes and cuttings common. Instances of settlement of unconsolidated, or wet, or weak soils. A few instances of liquefaction (ie. small water and sand ejections). Very small (≤103 m3) disrupted soil slides and falls of sand and gravel banks, and small rock falls from steep slopes and cuttings are common. Fine cracking on some slopes and ridge crests. A few small to moderate landslides (103 –105 m3), mainly rock falls on steeper slopes (>30°) such as gorges, coastal cliffs, road cuts and excavations. Small discontinuous areas of minor shallow sliding and mobilisation of scree slopes in places. Minor to widespread small failures in road cuts in more susceptible materials. A few instances of non-damaging liquefaction (small water and sand ejections) in alluvium.

MM8 *People*

Alarm may approach panic. Steering of motorcars greatly affected.

Structures

Building Type I, heavily damaged, some collapse*. Buildings Type II damaged, some with partial collapse*. Buildings Type III damaged in some cases. A few instances of damage to Structures Type IV. Monuments and pre-1976 elevated tanks and factory stacks twisted or brought down. Some pre-1965 infill masonry panels damaged. A few post-1980 brick veneers damaged. Decayed timber piles of houses damaged. Houses not secured to foundations may move, *and damage to earthenware sanitary fittings may occur*. Most unreinforced domestic chimneys damaged, some below roof-line, many brought down.

Environment

Cracks appear on steep slopes and in wet ground. Significant landsliding likely in susceptible areas.

Small to moderate (103-105 m3) slides widespread; many rock and disrupted soil falls on steeper slopes (steep banks, terrace edges, gorges, cliffs, cuts etc). Significant areas of shallow regolith landsliding, and some reactivation of scree slopes. A few large (105-106 m3) landslides from coastal cliffs, and possibly large to very large (≥106 m3) rock slides and avalanches from

steep mountain slopes. Larger landslides in narrow valleys may form small temporary landslide-dammed lakes. Roads damaged and blocked by small to moderate failures of cuts and slumping of road-edge fills. Evidence of soil liquefaction common, with small sand boils and water ejections in alluvium, and localised lateral spreading (fissuring, sand and water ejections) and settlements along banks of rivers, lakes, and canals etc. Increased instances of settlement of unconsolidated, or wet, or weak soils.

MM9 *Structures*

Many Buildings Type I destroyed*. Buildings Type II heavily damaged, some collapse*.

Buildings Type III damaged, some with partial collapse*. Structures Type IV damaged in some cases, some with flexible frames seriously damaged. Damage or permanent distortion to some Structures Type V. Houses not secured to foundations shifted off. Brick veneers fall and expose frames.

Environment

Cracking of ground conspicuous. Landsliding widespread and damaging in susceptible terrain, particularly on slopes steeper than 20°. Extensive areas of shallow regolith failures and many rock falls and disrupted rock and soil slides on moderate and steep slopes (20°-35° or greater), cliffs, escarpments, gorges, and man-made cuts. Many small to large (103-106 m3) failures of regolith and bedrock, and some very large landslides (106 m3 or greater) on steep

susceptible slopes. Very large failures on coastal cliffs and low-angle bedding planes in Tertiary rocks. Large rock/debris avalanches on steep mountain slopes in well-jointed greywacke and granitic rocks. Landslide-dammed lakes formed by large landslides in narrow valleys. Damage to road and rail infrastructure widespread with moderate to large failures of road cuts and slumping of road-edge fills. Small to large cut slope failures and rock falls in open mines and quarries.

Liquefaction effects widespread with numerous sand boils and water ejections on alluvial plains, and extensive, potentially damaging lateral spreading (fissuring and sand ejections) along banks of rivers, lakes, canals etc). Spreading and settlements of river stop-banks likely.

MM10 *Structures*

Virtually all Buildings Type I destroyed*. *Most* Buildings Type II destroyed*. Buildings Type III ∇ heavily damaged, some collapse*. Structures Type IV ∇ damaged, some with partial collapse*.

Structures Type V ∇ moderately damaged, but few partial collapses. A few instances of damage to Structures Type VI. Some well-built* timber buildings moderately damaged (excluding damage from falling chimneys).

Environment

Landsliding very widespread in susceptible terrain. Similar effects to MM9, but more intensive and severe, with very large rock masses displaced on steep mountain slopes and coastal cliffs. Landslide-dammed lakes formed. Many moderate to large failures of road and rail cuts and slumping of road-edge fills and embankments may cause great damage and closure of roads and railway lines. Liquefaction effects (as for MM9) widespread and severe. Lateral spreading and slumping may cause rents over large areas, causing extensive damage, particularly along river banks, and affecting bridges, wharfs, port facilities, and road and rail embankments on swampy, alluvial or estuarine areas.

MM11 *Structures*

All Buildings Type II ∇ destroyed *. Many Buildings Type III ∇ destroyed *. Structures Type IV ∇ heavily damaged, some collapse*. Structures Type V ∇ damaged, some with partial collapse.

Structures Type VI suffer minor damage, a few moderately damaged.

Environment

Environmental response criteria have not been suggested for MM11 as that level of shaking has not been reported in New Zealand or (definitively) elsewhere. As discussed in the text, it is likely that the MM scale in fact saturates between MM10 and MM11.

NOTES TO 2007 NZ MM SCALE

Items marked * in the scale are defined below.

CONSTRUCTION TYPES:

Buildings Type I (Masonry D in the NZ 1966 MM scale)

Buildings with low standard of workmanship, poor mortar, or constructed of weak materials like mud brick or rammed earth soft storey structures (e.g. shops) made of masonry, weak reinforced concrete or composite materials (e.g. some walls timber, some brick) not well tied together. Masonry buildings otherwise conforming to buildings Types I - III, but also having heavy unreinforced masonry towers. (Buildings constructed entirely of timber must be of extremely low quality to be Type I).

Buildings Type II (Masonry C in the NZ 1966 MM scale)

Buildings of ordinary workmanship, with mortar of average quality. No extreme weakness, such as inadequate bonding of the corners, but neither designed nor reinforced to resist lateral forces. Such buildings not having heavy unreinforced masonry towers.

Buildings Type III (Masonry B in the NZ 1966 MM scale)

Reinforced masonry or concrete buildings of good workmanship and with sound mortar, but not formally designed to resist earthquake forces.

Structures Type IV (Masonry A in the NZ 1966 MM scale)

Buildings and bridges designed and built to resist earthquakes to normal use standards, i.e. no special collapse or damage limiting measures taken (mid-1930's to c. 1970 for concrete and to c. 1980 for other materials).

STRUCTURES TYPE V

Buildings and bridges, designed and built to normal use standards, i.e. no special damage limiting measures taken, other than code requirements, dating from since c. 1970 for concrete and c. 1980 for other materials.

STRUCTURES TYPE VI

Structures, dating from c. 1980, with well-defined foundation behaviour, which have been specially designed for minimal damage, e.g. seismically isolated emergency facilities, some structures with dangerous or high contents, critical facilities which must remain operational after earthquakes, or new generation low damage structures.

WINDOWS

Type I - Large display windows, especially shop windows.

Type II - Ordinary sash or casement windows.

WATER TANKS

Type I - External, stand mounted, corrugated iron tanks.

Type II - Domestic hot-water cylinders unrestrained except by supply and delivery pipes.

H - (Historical) More likely to be used for historical events.

OTHER COMMENTS

“Some” or “a few” indicates that the threshold of a particular effect has just been reached at that intensity. “Many run outside” (MM6) variable depending on mass behaviour, or conditioning by occurrence or absence of previous quakes, i.e.may occur at MM5 or not till MM7. “Fragile Contents of Buildings”: Fragile contents include weak, brittle, unstable, unrestrained objects in any kind of building. “Well-built timber buildings” have: wall openings not too large; robust piles or reinforced concrete strip foundations; superstructure tied to foundation. ∇ Buildings Type III - V at MM10 and greater intensities are more likely to exhibit the damage levels indicated for low-rise buildings on firm or stiff ground and for high-rise buildings on soft ground. By inference lesser damage to low-rise buildings on soft ground and high-rise buildings on firm of stiff ground may indicate the same intensity. These effects are due to attenuation of short period vibrations and amplification of longer period vibrations in soft soils.