The impact of selective attention mechanisms on the

longevity of repetition priming in a lexical decision task

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Running head: SHORT AND LONG-TERM REPETITION PRIMING

Abstract

This study investigated repetition priming effects in a lexical decision task, and was designed as a follow up to a negative priming experiment conducted for my Honours' project last year. Similar to the previous experiment, a priming task was used whereby participants were required to make a verbal naming response to a prime target word, flanked by a distractor word, followed by a lexical decision response to a probe target word or nonword, flanked by a distractor word. The longevity of the repetition priming effect was explored in short and long lag conditions wherein stimuli were presented once and only once, except in order to fulfil the attended repetition conditions. The results evidenced a large immediate repetition priming effect. However, contrary to the results of the previous experiment where the negative priming effect was sustained for over eight minutes with many intervening trials, there was no evidence of facilitation in the current experiment after the same delay. Due to the perhaps surprising absence of long lag positive priming, further supplementary analyses involving compatibilities among the surface features between prime and probe displays were also conducted. The implications of the collective results for the understanding of selective attention and memory mechanisms are discussed.

Overview

Humans are continuously exposed to a large amount of visual sensory information and thus

mechanisms are needed to ensure that overload does not occur. Consequently, psychologists

have become interested in how humans apply strategies to distinguish between relevant and

irrelevant information and the processes or mechanisms that apply to them (Strayer & Grison,

1999). It has been established that covert responses, created automatically by visual

processes, can be induced without any conscious plan to do so. In order to control these non-

conscious responses, it is imperative that humans have the ability to inhibit responses that

may not be desirable for the current task (Tipper, 2001).

Negative Priming

The Stroop (1935) colour-word task, a classic selective attention paradigm, requires the

participant to respond to the colour of a printed word whilst ignoring distracting information

(such as the word being the name of a different colour). Distractor interference is evidenced

by a slower response time when the meaning of the word conflicts with the colour it is

printed in. It is generally accepted that this interference occurs due to obligatory automatic

word processing, whereby the meaning of the word is simultaneously processed with the

colour of the word, leading to a conflict, which in turn causes a slower response time. The

exact mechanism behind the resolution of this conflict is not yet known. Some researchers

advocate the role of selective inhibition of the distractor in resolving Stroop interference

(e.g., Schooler, Neumann, Caplan, & Roberts, 1997a; 1997b), whereas, others deny any

active inhibition of the distractor (e.g. Cohen, Dunbar, & McClelland, 1990; Cohen, Dunbar,

Barch, & Braver, 1997). In their early work, Neill (1977) and Tipper (1985) also proposed

that a distractor-suppression mechanism aids in resolving Stroop conflict. They further

maintain that selective attention involves not only excitation (activation) of relevant

information, but also the active inhibition of irrelevant information.

The negative priming phenomenon has been useful for investigating the mechanisms

underpinning visual selective attention and, in particular, the possibility that an active

inhibitory mechanism suppresses conflicting, 'to be ignored' information (e.g., Christie &

Klein, 2008; see Frings, Schneider, & Fox, 2015, for a review). A typical negative priming

experiment involves using trial couplets containing a prime display followed by a probe

display, with each containing a target stimulus that the participant responds to and an

irrelevant distractor that is ignored. The ignored repetition (IR) condition involves the

distractor in the prime display either matching, or being highly similar to, the target in the

probe display. In the control condition there is no relationship between the four stimuli in a

prime-probe couplet. Negative priming effects are evidenced by slower, or more error prone,

responses to IR trials compared to control trials. The observation that an ignored distractor

can influence later behaviour demonstrates that this distractor must be processed in some way

– either consciously or non-consciously. However, the exact mechanism as to how this occurs

is widely debated. There are two main theories of conceptual negative priming – inhibition-

based and episodic retrieval (e.g., Neill & Valdes, 1992).

Inhibition-Based Theory

The inhibition-based theory claims that momentarily irrelevant and distracting information is

actively inhibited as a function of target selection (e.g., Neumann & DeSchepper, 1991;

1992). Proponents of this theory contend that the inhibition of distracting information is as

necessary for selective attention as the activation of target information (see also Cerf et al.,

2010). A critical feature of the inhibition account of negative priming is that it operates in a

"forward" direction, starting at the prime display and continuing to the subsequent probe

display. When the prime stimuli are displayed, the ignored object is actively inhibited, and

this inhibition carries forward, creating impairment when the ignored item becomes a target

on the probe display (e.g., Fox & DeFockert, 1998). Additional support for this idea comes

from a study conducted by Pramme, Dierolf, Naumann, and Frings (2015) who investigated

the inhibition of distractors at the level of stimulus representation, using both behavioural

measures and, more directly, lateralized readiness potentials.

In the Pramme et al. (2015) study, distractor stimuli were either repeated from the prime to

the probe (distractor repetition), or not repeated (distractor change). A clear advantage was

found for distractor repetition when compared to distractor change, and this was referred to as

the distractor repetition benefit. The authors claimed that the distractor repetition benefit

occurs due to sustained inhibition from the prime display such that the inhibited state of the

distractor leads to less interference with the probe target. Due to the reduction of conflict,

there is no need for further processing of distractors on the probe display when the distractors

are identical to the prime distractors. Further, the onset of the probe distractor was varied so

that it occurred either 150ms before the probe target or simultaneously with the probe target.

Overall reaction times were faster when the distractor onset preceded the target onset,

compared to when the probe distractor and target were presented simultaneously. According

to the authors, this demonstrated an advantage for selection because presenting the probe

distractor prior to the target allows more time for processing and inhibition of the distractor,

ultimately leading to facilitation of target selection in both the distractor repeated and non-

repeated conditions. More importantly, when the control and distractor repeated conditions

were contrasted, it was found that the distractor repetition benefit was significantly greater

when the probe distractor was displayed simultaneously with the probe target, compared to

when the probe distractor appeared 150ms prior to the probe target. Collectively, these results

demonstrated that, in cases where the distractor precedes the target, the sustained inhibition

(causing the overall distractor repetition benefit) became superfluous due to the greater

advantage of more processing time between the distractor and target. Thus, when the

distractor was presented 150ms before the target, the distractor repetition benefit was almost

absent because inhibition of the distractor was more thoroughly completed by the time the

target was presented. Moreover, this result was supported by stimulus-locked lateralized

readiness potentials which had shorter onset latencies for distractor repetition than distractor

change when the probe distractor was presented simultaneously with the probe target. This

indicates that motor preparation for the target began earlier in cases where the distractor was

repeated compared to cases where the distractor was changed. However, this effect was not

present when the probe distractor was presented 150ms prior to the target. Overall, these

results support the idea that sustained inhibition of the distractor from the prime trial can

affect the response latency in the probe trial. More recently, Cunningham and Egeth (2016)

have shown that suppression of multiple distractors on the basis of a distinguishing feature

such as colour, can also result in benefits when processing subsequent target stimuli.

Together, these findings are consistent with earlier evidence showing benefits of distractor

repetition when the same distractors appear in both prime and probe displays (Christie &

Klein, 2008; Neumann & DeSchepper, 1991; Stadler & Hogan, 1996).

Episodic Retrieval Theory

The episodic retrieval theory of negative priming was proposed by Neill and Valdes (1992)

after a series of experiments in which a decrease in the magnitude of negative priming was

found as response-to-stimulus intervals (RSIs) increased. This relationship was demonstrated

by an exponential decay function whereby differences in negative priming would be harder to

detect at long RSIs as opposed to short RSIs. Neill and Valdes (1992) discovered that this

decay function of negative priming was similar to characteristic decay functions that have

been reported for both sensory memory (Sperling, 1960) and short-term memory (Peterson &

Peterson, 1959). Logan's (1988) theory of automatization proposed that behaviour, and

therefore subsequent performance, can be mediated by the retrieval of prior processing

episodes involving the same stimuli. In line with Logan's ideas, the episodic retrieval

account of negative priming suggests that task reaction times can vary due to retrieval of

certain episodes. These episodes contain both identity information and information

pertaining to whether the prime display item was previously a target (respond tag) or a

distractor (do not respond tag). Hence, when the probe trial is displayed, the memory of the

previous prime trial is elicited and interferes with the response in IR trial couplets where

there are conflicting response tags (i.e., "do not respond", "respond"). It is the extra time

required to overcome the conflicting tags in the IR condition, compared to the control

condition, which produces negative priming. Unlike the inhibition account, episodic retrieval

works in a "backward" direction with the probe trial target acting as a memory retrieval cue.

Attempted Reconciliation between Episodic Retrieval and Inhibition-Based Perspectives

Tipper (2001) attempted to reconcile the opposing views inherent in the episodic retrieval and

inhibition-based accounts of negative priming, by pointing out that both encoding factors

(affecting prime display processing) and memory retrieval factors (affecting probe display

processing) are necessary for a more accurate and complete theory of what underlies the

negative priming effect. Tipper holds that the inhibition-based account and the episodic

retrieval account are not mutually exclusive, but rather should be integrated. More

specifically, when a probe target is presented on an IR trial, prior processing episodes

associated with that word will be retrieved. These will include both information about the

stimulus, and a reinstatement of the internal representations of the distractor. These

representations result from selective attention mechanisms acting upon the stimulus when it

appeared moments before as a prime distractor. Given that the probe target was inhibited

when it appeared as a prime distractor, it follows that the retrieved episode will also include

that inhibitory or suppressive process. Tipper further argues that traditional accounts of

inhibition place too much focus on the encoding process, whilst the episodic retrieval account

over emphasizes the retrieval process. Consequently, a complete view of the inhibition-based

and memory-based processes involved in negative priming should include accounts of what

transpires at both encoding and retrieval.

Repetition Priming

Repetition priming is a phenomenon whereby presentation of a stimulus facilitates processing

on subsequent presentation of the same stimulus. Thus repetition priming is evidenced by a

faster, or less error prone, response to stimuli that have previously been presented compared

to new stimuli. The repetition priming literature indicates that there are two components to

repetition priming; a short term component, and a long term component. The short term

component is most evident in the masked form priming paradigm whereby the prime is

displayed very briefly preceded by a mask, and immediately followed by a target probe,

making it unable to be consciously identified. This type of repetition priming encourages the

prime and target to merge into one event and the resulting facilitation from masked stimuli

has been shown to disappear if more than a few items intervene between the prime and the

target (Forster & Davis, 1984). In contrast, repetition priming can be long-lasting when the

prime and target are experienced as separate events. For example, it has been found that

repetition priming in a lexical decision task was evident after a 2-day delay (Scarborough,

Cortese, & Scarborough, 1977). As such, both of these studies suggest that short- and long-term repetition priming effects are observable.

Two major theories have been proposed to account for repetition priming using word stimuli. The first is referred to as an abstractionist account whereby repetition priming is said to occur due to an increase in the accessibility of a word's abstract lexical representation. For example, Morton (1969) proposed the logogen model whereby the presentation of a word lowers the threshold of that word's logogen (abstract lexical representation), thus making it more accessible at second presentation. The second theory is an episodic account. This theory posits that facilitation occurs due to retrieval of a recent episode of an encountered stimulus. This episode is said to be more accessible than older episodes of the same stimulus.

The impact of altering the surface features of stimuli

There have been extensive research attempts to distinguish between the abstractionist and retrieval accounts of repetition priming. For example, it has been suggested that changing the surface features of stimuli such as type case, font, and orientation may shed some light on the mechanisms underpinning the repetition facilitation effect. The abstractionist model would predict that the same amount of facilitation should occur regardless of whether the surface features are the same or different between prime and probe displays. Conversely, the episodic account would predict significantly greater facilitation in situations where the surface features of the stimulus at first presentation are repeated at the second presentation. Graf and Ryan (1990) examined this in a series of experiments that manipulated different surface features of items between prime and probe displays. Participants first experienced a study phase where they were required to read aloud the word shown on an index card that was presented for two seconds. Subsequently, a word identification phase was employed

whereby participants were required to read aloud a masked word on a computer screen.

Repetition priming was evidenced by an increase in identification performance of words

presented in the study phase compared to new words. In the first experiment, words in both

phases were either presented upside down (U) or normally (N). It was found that significant

repetition priming was evident in all conditions. More importantly, there was no difference

in the priming effect when the words were the same in study and identification (U-U or N-N)

compared to when they were different (U-N or N-U). These results demonstrated that the

magnitude of priming was not mediated by substantial changes in the surface features of

words between study and test, as would be expected by an episodic account. The authors

also conducted a second experiment in which the study and test words were presented either

upside down (U) or backwards (B). Again, repetition priming was evident in all conditions.

However, it was found that the magnitude of this effect was greater when the study and test

formats were the same rather than different, but only for words tested in the B format (B-B

vs. U-B). The same-different effect was not evident for words tested in the U format (U-U vs

B-U). Overall, the study shows mixed results and suggests that the effect on repetition

priming may vary depending on which surface features are manipulated.

An additional study by Manso DeZuniga, Humphreys, and Evett (1991) investigated the

effect of changing surface features between prime and probe displays on repetition priming

and whether this effect differed between short and long-term priming. A lexical decision task

was used where one trial consisted of two temporally separated letter strings. The first string

was always a word. The second string was either a word or a nonword. Participants were

required to read the first word aloud and make a lexical decision on the second item. The

first and second items were either presented immediately one after the other or had a lag of

15 intervening trials. They were either hand or typewritten, in equal numbers, across both

prime and probe components. In the immediate conditions, it was found that in respect of

handwritten probe targets, the magnitude of repetition priming was greater when the prime

display was also handwritten compared to when the prime was typewritten. However, for

typewritten probe targets, the magnitude of priming was not significantly different whether

the prime was handwritten or typewritten.   In the lag 15 condition, there was also evidence

of significant repetition priming. However, the magnitude of the repetition priming was not

affected by whether the prime and probe displays were presented in the same or differing

formats. The authors suggested that different mechanisms may contribute to short versus

long term repetition priming effects.   Specifically, it was proposed that the lagged repetition

effect was most likely due to persistent activation in the lexical system. They also suggested

that it is probable that the effects found in the immediate condition are attributable to an

advantage of the episodic representation of the prime display being identical to the probe

display. It was further suggested that over the lag interval, the episodic representation of the

prime display decays, or is overwritten, such that the extra benefit of contextual similarity is

eliminated.

A common argument against an abstractionist approach to repetition priming is that priming

has been reliably found with pseudowords (Bowers, 1996). As pseudowords are novel

stimuli they have no previous representation in memory. Therefore priming for these items is

said to reflect new representations that are acquired during the experimental session.

However, Bowers (1996) suggested that it cannot be assumed that the same types of

representations and mechanisms are responsible for priming of different types of materials.

In fact, he claimed that different mechanisms may be responsible depending on the

circumstances at the time. The experiment involved the use of high-shift and low-shift

words. Low-shift words were defined as words composed of letters that are visually similar

in upper and lower case i.e. c/C, i/I, o/O, p/P, s/S, u/U, and w/W. In contrast, high-shift

words were composed of letters that are visually different in upper and lower case i.e. a/A,

d/D, e/E, g/G, n/N, q/Q, and r/R. All words were four letters in length and were either

studied and tested in the same case, or studied and tested in different cases. During the study

phase, participants were asked to pronounce the words aloud and count the number of vowels

and enclosed spaces in each word. An enclosed space was defined as an area within a letter

that could be coloured in. Following this, they completed a perceptual identification task

where a word was presented briefly, and they were asked to respond by recalling the first four

letters that came to mind. This word was masked both immediately before, and for 1 second

after, by a pattern mask. Significant repetition priming was found in all conditions. Further,

the magnitude of this priming effect was similar for high-shift words in the same versus

different format, and for low-shift words in the same versus different format. Thus, similar

facilitatory priming was obtained in all conditions and word priming was insensitive to the

case manipulation. Bowers concluded that his results demonstrate that orthographically

abstract representations likely mediate priming with word stimuli. In addition, a second

experiment was conducted using the same procedure except instead of low- and high-shift

words, low- and high-shift pseudowords were used. Comparable priming was evident for

low-shift pseudowords studied and tested in the same case and in different cases. However,

for high-shift pseudowords, the magnitude of priming was substantially greater when these

pseudowords were tested in the same case rather than different cases. Taken together, these

results indicate that different mechanisms mediate priming for words and pseudowords.

Overall the research is divided as to whether holding surface features constant between prime

and probe displays has an effect on the magnitude of repetition priming. The above

experiments demonstrate that different mechanisms may underlie the short and long term

repetition effects. Further the effect of surface feature similarity on the magnitude of

facilitation seems to depend on which surface features are manipulated.

Long-term Repetition Priming

In support of episodic retrieval theory, Bentin and Moscovitch (1988) conducted a series of

experiments that explored the time course of repetition priming effects for words and

unfamiliar faces at lags of 0, 4, and 15 items between first and second presentations. The

first experiment involved a lexical decision task whereby both words and nonwords were

assessed for priming effects over the three lags. This experiment also included a task

requiring participants to respond as to whether an unfamiliar face or "nonface" was a normal

human face. The nonfaces were made by switching the locations of certain features i.e. eyes,

nose, and mouth. All four categories of stimuli produced significant repetition effects at Lag

0. Conversely, only words produced significant repetition effects at lags of 4 and 15

intervening stimuli. The authors suggested that although these results are consistent with a

logogen model they may also be consistent with a memory perspective, given that the first

presentation of an unfamiliar stimulus (i.e., nonword, unfamiliar and scrambled faces) may

have been unable to create a strong enough memory trace to sustain effects at longer lags.

They suggested that real words are processed more deeply due to their familiarity, especially

if lexical decisions are involved, thereby creating stronger memory traces. Given that the

face or nonface task does not require deep processing, participants may have focused only on

superficial features leading to the formation of a reasonably "weak" memory trace. To test

this assumption, the authors conducted a second experiment to establish whether the

repetition effect found for words at long lags can be eliminated if the task constrains the

participants to attend to the superficial attributes of the words rather than to deeper internal

representations. In this experiment, participants were required to determine whether the first

and last letter of each word or nonword was in alphabetical order. This new paradigm

demonstrated no evidence of repetition priming at lags greater than 0 for either words or

nonwords. Overall, the authors concluded that items with a pre-experimental representation

(i.e., real words) are more likely to produce a repetition effect due to their ability to create a

stronger and more accessible trace in memory.

Additional support for an episodic retrieval perspective comes from a study that explored

repetition word priming in a lexical decision task over lags of 0, 1, 4, or 8 intervening stimuli

(Kersteen-Tucker, 1991). Participants were advised that they would see a series of letter

strings appearing on the screen and that they needed to respond as to whether the letter string

constituted a word or not. It was found that there was significant repetition priming at all

lags but that the magnitude of the effect at lag 0 was greater than at all other lags

independently. The authors concluded that the long-term repetition effect was consistent

with the idea of participants retrieving a consciously accessible episodic record of the first

presentation of the stimulus.

It has been argued that an abstractionist model of repetition priming struggles to explain

long-term repetition effects. If the lexical unit of a word could remain more accessible for a

long period of time, the number of these "accessible units" would become extremely large

making this explanation improbable. It has been suggested that the lexicon is ordered by

frequency and recency (Taft and Forster, 1976) yet this explanation similarly struggles to

explain a long-term effect. Any words intervening between the first and second presentation

of the target would push the target word backward making it unlikely to produce facilitation.

There are also arguments as to why the episodic retrieval theory may have difficulty in

explaining long-term repetition priming. This is most evident in research that extends

priming over a longer time period than has been discussed so far. Wheeldon and Monsel

(1992) argue that in the case of word recognition, it seems implausible that episodic retrieval

would have time to operate given that in the majority of reaction time experiments unprimed

performance is fast and accurate. This is especially true in the case of experiments with long

lags between prime and probe displays. These authors designed a series of experiments in

order to minimize the chance of episodic retrieval occurring. They achieved this by creating

a design where performance was efficient and fast leaving very little time following the

prime trial for elaborative encoding. Further, they included many new intervening items

between the prime and probe, and gave no explicit encouragement to expect any kind of

repetition. The design was such that the stimulus on the prime trial was not repeated on the

probe trial. This was achieved by using a picture naming task. In the first experiment,

participants were asked to respond by producing a spoken word to the picture probe. They

had been primed previously with either a definition prime (a definition appeared on the

screen and they responded with the word) or a printed word prime (they read the word on the

screen). This stimulus change, between prime and probe, was employed to decrease the

chance that the probe stimulus could elicit an episodic memory of the prime stimulus. There

was a short lag condition where prime and probe trials were separated by $2 - 7$ intervening

trials, and a long lag condition where they were separated by $60 - 120$ intervening trials.

Significant facilitation was observed at both short and long lags when the same word had

previously been overtly produced in response to a definition or reading a printed word aloud.

Facilitation was greater at short lags, however the authors reported that the long lag effect is

consistent with a persistent change in the state of the processing pathway. It is still unclear

what specifically comprises that change and how the change occurs. It may be that

production of a phonological form is facilitated by the prior production of that phonological

form. Alternatively, when the participants produced the word at the prime stage, this

activated the appropriate meaning and it is the meaning itself that is facilitated.   It is also

possible that facilitation occurs due to a combination of both – that is the phonological form

is more easily retrieved when there has been prior rehearsal of the link between the meaning

and phonological form.

Wheeldon and Monsel (1992) further investigated whether it was plausible that the

production of a phonological word form was facilitated by the prior production of that

phonological form. Their second experiment compared repetition priming and homophone

priming. In homophone priming, the word form generated at the prime is in response to a

different meaning. If the long-term repetition priming effect found in their first experiment

was purely due to production of the same phonological form, the homophone priming

condition should show significant facilitation. The stimuli used were homophonic pairs (e.g.,

break and brake) with some of the pairs being homographic (e.g., bow and bow) and some

being heterographic (e.g., knight and night). There was no evidence of homophone priming.

Interestingly, there was evidence of some facilitation in the homophone condition where the

pairs used were homographic (although this did not reach significance). Heterographic pairs

by contrast, showed no facilitation. These results suggest that prior production of the same

phonological word form does not produce facilitation over long lags.

Long-Term Negative Priming

In contrast to long-term repetition priming, considerably less research has been undertaken

into long-term negative priming. The first study to explore the idea of long-term negative

priming was conducted by DeSchepper and Treisman (1996) who used overlapping novel

shapes, distinguished by colour, in a same-different decision task to establish the existence of

long-term negative priming after lags of 1, 10, 100, and even 200 trials. Similarly, Grison et

al. (2005) found long-term negative priming, after an average delay of 3 minutes, using

experimentally novel face and object stimuli. These results clearly support DeSchepper and

Treisman's (1996) observation of long-term negative priming, but also extend long-term

negative priming effects to meaningful stimuli rather than novel "blob" shapes. Grison et al.

(2005) concluded that memory processes were important in long-term negative priming, but

considered it improbable that sustained inhibition could be maintained over a delay as long as

3 minutes, while attending to many other intervening stimuli. They also discuss the

possibility that long-term negative priming is dependent on the subject being able to retrieve

only one prior instance of the ignored distractor. This is consistent with the results of

DeSchepper and Treisman (1996) who used novel shapes, making it unlikely that the subject

had any previously stored instances of the stimuli. Treisman and DeSchepper (1996),

however, reported no significant long-term negative priming with meaningful word stimuli

using a same-different matching task with words distinguished by different colours. They

concluded that the many previous interfering tokens attached to words in memory reduced

the likelihood of observing negative priming. A similar point was made by Tipper and

Milliken (1996) who reported "unpublished studies conducted in our laboratory consistently

failed to show negative priming effects with lags between the prime and probe displays in

excess of 7 s" (p. 341). These studies used stimuli previously seen by participants thereby

having multiple representations attached to them in memory. The authors concluded that

because of the mixture of "respond" and "do not respond" tags attached to distractor items,

these multiple representations interfered with retrieval of the appropriate episode.

Honours' Experiment

My Honours' experiment conducted in 2016 employed a task previously used by Neumann,

McCloskey, and Felio (1999). The task involved naming a prime target followed by a lexical

decision (i.e., word or nonword judgement) to the probe target. In prime and probe couplets

lower- and upper-case items appeared immediately above or below one another. Each prime

and probe selection display consisted of an upper-case distractor word and a lower-case

target, both printed in black. The upper-case distractor was always a word, but the lower-

case probe target was a word in half of the trials, and a pronounceable nonword in the

remaining trials.   Target and distractor items were placed one above the other with minimal

separation. As with Neumann et al. (1999), target and distractor were distinguished only by

font case. The ability to parse displays into target and distractor was further challenged by

varying the location on the screen of prime displays (Langley, Overmier, Knopman, &

Prod'Homme, 1998). Like Neumann et al., participants were required to name the lowercase

word in prime displays while ignoring a competing uppercase distractor that appeared at

random above or below the target. Similarly, probe targets were displayed in lowercase in the

presence of a competing uppercase word, but equally often probe targets formed English

words or pronounceable pseudo-words and required a lexical decision response. The most

critical novel manipulation in my study involved the temporal dimension of the negative

priming phenomenon, specifically, whether long-term negative priming for words could be

obtained. The IR condition involved the uppercase distractor in the prime display becoming

the lowercase target in the probe display. In the unrelated control condition, there was no

relationship between the four stimuli in the prime-probe couplet. In the long lag IR

condition, the uppercase prime distractor in one trial became the lowercase probe target 144

trials later. Negative priming effects were evidenced by slower response latencies to IR trials

compared to unrelated control trials in both short and long lag conditions, with no discernable

difference in the magnitude of the observed negative priming effect (see Figure 1). To my

knowledge, this was the first observation of long lag IR negative priming with meaningful

word stimuli.

Several design characteristics were employed to heighten the likelihood of obtaining negative

priming in my experiment. For example, the change in response requirement from naming in

the prime display to a lexical decision in the probe display was designed to increase

attentional demands. This is important because it has previously been established that the

magnitude of negative priming tends to increase when the attentional state is heightened (e.g.,

Moore, 1994; Pritchard & Neumann, 2011; Tipper & Cranston, 1985). Similarly, the word-

case selection cue, spatial uncertainty of the prime display, and the close proximity of the

target and distractor in each display were designed to induce consistent selection difficulty in

an experiment-wide manner. Further, a short prime display timing (200ms) was designed

specifically to increase attentional demands. This is known to increase the likelihood of a

negative priming effect being observed (e.g., Neumann & DeSchepper, 1991; Wyatt &

Machado, 2013). From the present perspective, these efforts combined to produce the

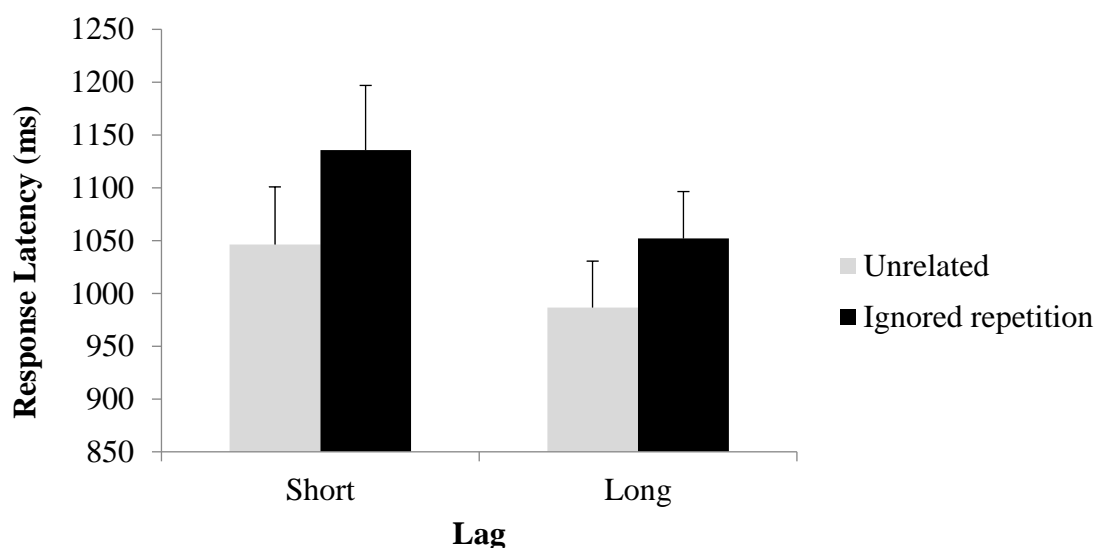circumstances under which a long lag IR negative priming effect with words should be

obtained.

Figure 1. Mean response latency (in milliseconds) as a function of interval and priming.
Error bars indicate standard error of the mean.

In Figure 1, negative priming was evident over a lag of 144 intervening trials (288 selective

attentional displays) and further, the magnitude of this effect did not significantly differ from

the immediate negative priming effect found. To my knowledge, this was the first

documented finding of a lasting negative priming effect using common word stimuli.

Although Grison, Tipper, and Hewitt (2005) found long-term negative priming when using

experimentally novel face and object stimuli, they concluded this was due to memory

processes as it was inconceivable to them that the inhibition of the prime distractor

information could have been maintained over the delay. Further, the stimuli used by Grison et

al. (2005) were novel so participants would have had no prior representation of these stimuli.

Yet in my Honours' experiment, negative priming was found despite the fact that common

word stimuli would carry many pre-experimental representations in memory.

Many researchers have claimed that it is unlikely that inhibition lasts through the interference

of many intervening trials (Grison et al., 2005; Treisman & DeSchepper, 1996). However, at

this stage, the possibility that inhibition is the proximal cause of negative priming cannot be

ruled out. For example, the consequences of having suppressed a prime distractor may result

in a raised threshold of activation for such distractor representations (Neumann &

DeSchepper, 1991). In effect, this could yield negative priming effects that last over the

course of minutes and many intervening stimuli.

In terms of the interpretation of long-term negative priming from an episodic retrieval

perspective, a possible argument is that when the probe was presented, the most recent

memory of that stimulus would be retrieved. Although this appears to be a plausible

explanation, Treisman and DeSchepper (1996) claim that the recency effect in retrieval

disappears within two trials such that if the presented object was seen more than two trials

earlier, it will be just as likely that the retrieval of that item will elicit an "attend" tag as an

"ignore" tag. Consistent with this, memory research shows that the recency effect is

cancelled out if there are intervening working memory tasks that exceed 15–30 seconds in

duration (Bjork & Whitten, 1974). With respect to the long lag negative priming effect found

in the Honours' experiment, it is possible that the relevant context occurred eight minutes

beforehand. Although the task involved a response change between the prime and its coupled

probe, as well as a change from upper-case to lower-case letters, it could be argued that other

features (e.g., two words always shown on the screen, the same size and colour of the font

was always used, and the subjects always responded to the lowercase word and ignored the

uppercase word) made the encoding and retrieval contexts similar. This similarity between

the prime and probe episodes could have made the retrieval of the prime episode with a "do

not respond" tag attached more accessible and in this case, episodic retrieval would predict

long lag negative priming. Thus, the results from the Honours' experiment could be

explained either by an inhibition or by an episodic retrieval account.

Current Experiment

The current experiment aims to pursue these alternative explanations by using a repetition

priming task that is identical to the task used in the Honours' experiment, with the exception

that it tests for short and long lag attended repetition positive priming effects, instead of IR

negative priming effects. An attended repetition (AR) trial involved the target on the prime

trial being identical to the target on the probe trial. In this case, repetition priming would be

evidenced by a faster, or less error prone, response to the AR conditions compared to the

unrelated condition. In the current experiment the long lag AR manipulation occurred with

exactly the same number of intervening trials as in the IR negative priming study. Moreover,

all word lists, timing of stimuli, presentation of stimuli, and response requirements were

designed to match the previous IR experiment. The only difference in the current experiment

was that the word lists from the previous IR condition were used in the current AR condition.

The only substantive change between these experiments was to swap the status of the IR

prime trial words so that the uppercase word became the lowercase word, and vice versa in

the present experiment (see Table 1).

Table 1. A sample of the IR condition from the Honours' experiment and the AR condition
from the current experiment

	Prime Display	**Probe Display**
IR Experiment	debt	box
	BOX	CLASS
Current Experiment	box	box
	DEBT	CLASS

Note. The target appears in lowercase whilst the distractor appears in uppercase. The only
difference between the two experiments is that the target and distractors in the prime display
are flipped.

If the long lag negative priming observed in the previous experiment can be explained by an

episodic retrieval account, it would be expected that both short and long lag AR positive

priming are observed in the current experiment. At the presentation of the probe trial, the

prior episode of similar context (the prime trial) should be retrieved with a "respond" tag

because the prime and probe target words would be identical and thus should lead to

facilitation. Indeed, there is actually greater similarity between the prime target and probe

target in the current AR experiment, compared to the IR experiment.   In the AR experiment,

the word and font were identical whereas in the IR experiment there was a font change from

uppercase to lowercase letters between prime and probe targets. According to episodic

retrieval theory, the similarity between the prime and probe targets in the AR experiment

should create conditions where it is highly likely that the probe target is able to elicit the

prime target attached to the 'respond' tag. Accordingly, if anything, episodic retrieval would

predict a greater likelihood of obtaining positive priming in the current AR experiment

compared to obtaining negative priming in the IR experiment.

Method

Participants

There were fifty-four (43 female, 11 male) participants aged 17–46 years. Twenty students

participated to fulfil credit for an introductory psychology course while the remaining 34

participants were recruited from the University of Canterbury and the general public. These

participants were rewarded with a $10 grocery voucher for their participation.

Stimuli and Apparatus

On each trial participants first saw a small fixation cross in the centre of the screen for 500

ms. This was followed after a 200 ms blank screen by the prime display which was visible for

200 ms. The screen then remained blank for 1000 ms to allow participants time to name the

prime target word aloud before the probe display appeared. The probe display remained on

the screen until the lexical decision response was registered. This cycle was repeated

throughout the experiment. A more detailed description and examples of stimulus layout for

the AR, unrelated control, and nonword trials are presented in Figure 2.
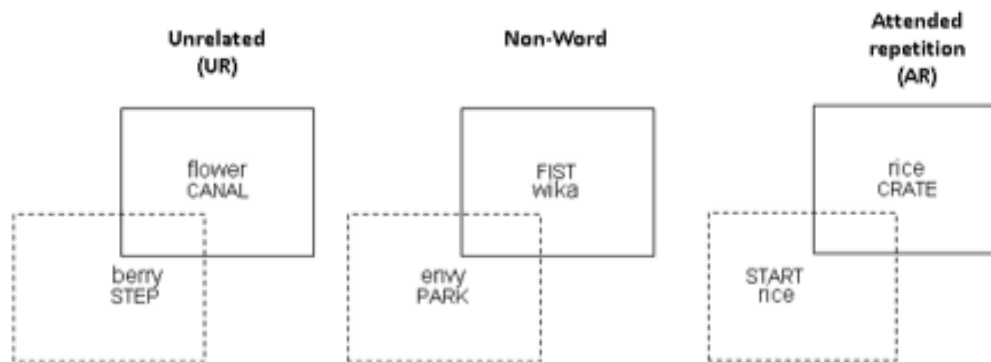
Figure 2. Sample trial conditions. For prime displays (dashed outline) participants named the lower case word (target) while ignoring the upper case word (distractor). Prime displays were visible for 200 ms. The probe display followed 1000 ms later. For probe displays participants made a lexical decision to the lowercase string (target and the probe display remained visible until a lexical decision response was registered. On attended repetition trials the prime target word became the target of a lexical decision on the immediately following probe display (note the repetition of "rice"); on unrelated control trials there was no relationship between words on prime and probe displays; on nonword trials (half of all trials) the probe target was not an English language word. On every display the spatial separation between target and distractor items was determined by the need to avoid overlap of lowercase ascenders and descenders with adjacent uppercase words. All upper case and lower case items were separated by the distance necessary to allow one screen pixel between the ends of ascenders or descenders and the top or bottom of the adjacent upper case word (see the unrelated prime displays for an example of the need to avoid overlap with lowercase ascenders and descenders, and note the absence of ascenders and descenders in the unrelated probe display in this example).

Stimuli were presented on a Philips 19-inch LCD monitor in Arial 20pt font. The prime stimuli were positioned across trials either on the left, right, or centre of the screen such that they appeared 1/3 of the time in each position. Probe displays were always presented in the centre of the screen. When the prime was presented on the left, the visual angle of the space between the rightmost edge of the prime and the leftmost edge of the probe was 1.5°. Similarly, when the prime was presented to the right there was a 1.5° angle between the leftmost edge of the prime and the rightmost edge of the probe. Target and distractor words were presented one above and one below pseudo-randomly, such that 50% of the time the target appeared in the upper position. The experiment was generated using E-Prime 2.0. The

E-Prime software enabled a separation distance between the target and distractor stimuli such that their closest edges were always 1 pixel width apart.

From a pool of 1080 3- to 8-letter nouns, verbs, and adjectives, 240 words were randomly chosen as targets, and the remaining 768 words were used as filler words. Nonword stimuli consisted of one-hundred and forty-four pronounceable nonwords that were 3-7 letters in length. All stimuli were presented once and only once except in order to fulfil the AR conditions. Target words were always presented in lower-case letters and distractor words in upper-case letters. The word pool used for this experiment was identical to the word pool used in the IR experiment. The only modification was that the words used for the IR conditions in the previous experiment were used for the AR conditions in the current experiment (see Table 1).

Prior to the main trials, all participants completed 24 practice trials. Twelve were nonword trials and 12 were unrelated control trials (there were no AR trials during practice). Prime displays were initially presented for 500 ms reducing to 400 ms and then to 200 ms from the 9th trial onwards as participants became familiar with the task. There were 288 trials in the experiment proper. Of these 144 were nonword trials and the remaining 144 trials were configured as follows: 48 unrelated control trials, 48 long lag AR trials (24 filler lag, 24 long lag AR), 24 short lag AR trials, and 24 word filler trials. To clarify, the long lag manipulation required 48 "trials" as each of the 24 analysed probe trials required a linked prime trial 144 trials earlier to make the manipulation possible. For example, in the first half of the experiment one of the trials we referred to as "filler lag" had the prime target "grass" and 144 trials later, the probe target was "grass". This represents a long lag AR trial. The "filler lag" trials were inserted for the purpose of the lag manipulation and were not analysed. As such,

there were 24 trials in each of the four conditions. This was identical to the trial structure

used in the previous IR experiment with the only difference being that the long lag AR trials

were long lag IR trials and the short lag AR trials were short lag IR trials.

 Half the trials were "word" trials, the remaining half were "nonword" trials. The

experimenter recorded the participant's verbal response to the prime target on a response

sheet (see Appendix). The criteria for a naming error was lenient such that for a naming error

to be recorded the participant must have either failed to name any word or failed to name a

word that began with the same letter or sounded like the prime target word. Trials on which a

naming error was committed were removed from further analysis.

Design

A within-subjects design was employed in which the dependent variables were lexical

decision times and lexical decision error rates. The independent variables were priming

(unrelated control vs. AR), and lag (short vs. long). In the short lag AR, prime and probe

displays followed immediately whereas in the long lag AR condition, 144 trials intervened

between the prime and the probe displays. Table 2 shows a sample of the long lag AR

condition.

Table 2

A sample of the long lag AR condition

Prime Display	Probe Display		Prime Display	Probe display
prison	blob	144 intervening	vacancy	prison
WARRIOR	CLOD	trials	INCH	GRASS

Note. The prime target is the same word as the probe target 144 trials later.

Three versions of the experiment were created for the purpose of counterbalancing. The 144

probe target words were randomly divided into sets A, B, C, D, E, and F of 24 words each.

Participants were assigned at random to one of three groups to achieve counterbalancing. The

experiment was divided into two halves for counterbalancing as no comparisons were made

between the first and second half trials. In the first half of the experiment, participants in

Group 1 experienced Set A as AR trials and set B as unrelated control trials; Group 2

experienced set B as AR trials, and set C as unrelated control trials; and for Group 3 set C

were AR trials, and set A were unrelated control trials. In the second half of the experiment,

participants in Group 1 experienced Set D as AR trials and set E as unrelated control trials;

Group 2 experienced set E as AR trials, and set F as unrelated control trials; and for Group 3

set F were AR trials, and set D were unrelated control trials. Across participants, therefore,

each probe target word served as a probe target equally often in the short lag AR, short lag

unrelated control, long lag AR, and long lag unrelated control conditions. Moreover, no

word appeared more than once during the experiment, except to fulfill the AR manipulations

in the short lag AR and long lag AR conditions. The entire trial set comprising 144 word and

144 nonword trials (common to all groups) was arranged in random order. The same random

order was used for all participants, regardless of group.

The final trial was a catch trial which was included to identify whether participants were able

to recall or recognize the prime distractor. The prime display was presented in the same way

as the previous prime displays. However, instead of a probe display, a blank screen appeared

and the participant was given 5 seconds in which to name the prime distractor on the previous

display. If they were unable to do so, they were asked to select the prime distractor from a

display of five upper-case words (i.e. GLARE, GAUGE, GRATE, GUIDE, GRIPE) that had

the same beginning and end letter as the prime distractor.

Procedure

Participants were tested individually in a quiet dimly lit room. Following description of the task, participants signed an informed consent form. They were then given printed and verbal instructions to name the lowercase word on each prime display and to ignore the uppercase word as best they could and to make a lexical decision on the lowercase item on probe displays as quickly as possible while trying not to make any errors. Participants were informed of naming, lexical decision, and procedural errors during practice trials. No feedback was given during the main trials. Participants were asked to make the lexical decision response on a Mitsumi electronics serial mouse. If the stimulus presented was a "word" participants were asked to press the left button with their index finger, and if the stimulus was a "nonword", they were asked to press the right button with their middle finger.

The experiment consisted of 289 trials (including the catch trial) and on average took participants 25 minutes to complete. After the completion of 144 trials, there was a break of approximately one minute before the second half of the experiment began. Participants were informed of this and were asked to press the spacebar to begin trials again when prompted by the experimenter. At the commencement of the second half, all participants completed six warm-up trials that were not analyzed.

Results

Trials involving either commission or omission naming errors were treated as failures of selective attention and were removed from the reaction time (RT) analyses, as were trials where participants committed a lexical decision error. By definition, investigating mechanisms of selective attention requires participants to selectively process a target stimulus in the midst of nontarget information. In the current task, confirmation of successful prime

target selection is supplied by a correct prime target word naming response. This is a minimal

mandate required by both the inhibition-based and episodic retrieval theories. Cut-offs for

naming and lexical decision errors were 18% and 25% respectively in order to match the

cutoffs used in the earlier IR experiment. Three participants failed to meet these criteria (all

for naming errors). A further six participants were eliminated from further analysis due to a

lexical decision rate exceeding 20% in at least one of the unrelated control or AR conditions

although their total lexical decision error rates were below 25%[1]. These six participants did

not exceed the overall cut-offs of 18% (naming errors) and 25% (lexical decision errors).

Forty-five participants remained, 15 per counterbalancing group.

RT Analysis

Figure 3 shows the means and standard errors of the four conditions. A 2 (priming: unrelated

control vs. AR) x 2 (lag: short vs. long) repeated measures analysis of variance confirmed

that RT was faster in the AR conditions compared to the unrelated control conditions, $F(1,

44) = 32.161$, $p < 0.01$, $\eta^2 = 0.422$. There was no statistically significant difference between

RT in the short lag conditions compared to the long lag conditions, $F(1, 44) = 1.225$, $p =

0.274$, $\eta^2 = 0.027$. Importantly, the lag x priming interaction was significant $F(1, 44) =

27.997$, $p < 0.01$, $\eta^2 = 0.389$ indicating a difference in the magnitude of AR facilitation

between the short and long lag conditions.

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[1] It should be noted that data were also analyzed before an error rate was separately set for each condition. This meant that only three participants were excluded. All trends in the data were the same under these more lenient exclusion conditions, and the statistical outcomes did not alter the interpretation of the results.
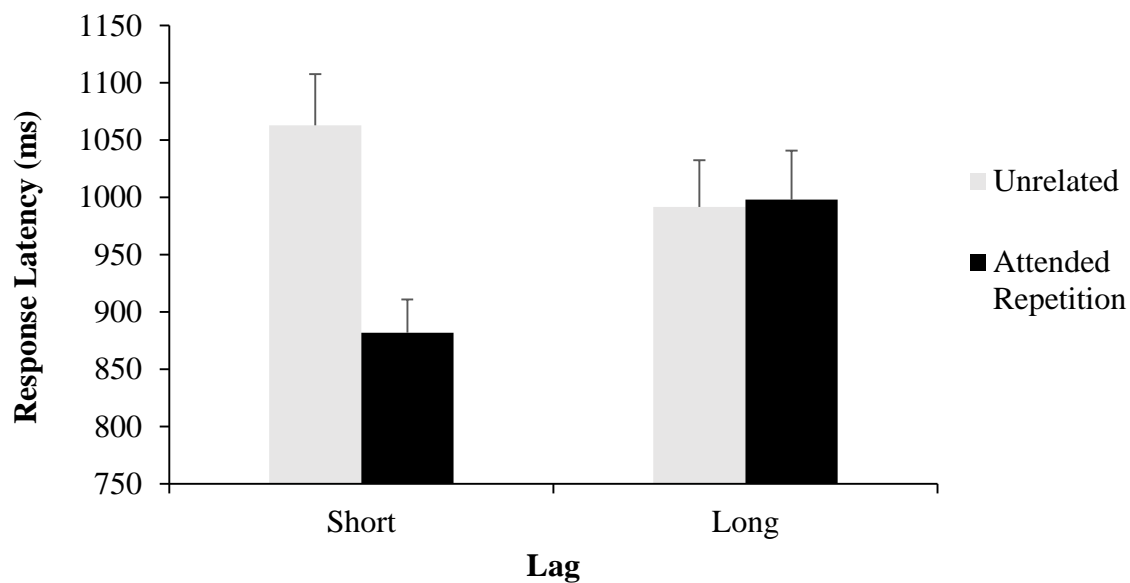
Figure 3. Mean response latency (in milliseconds) as a function of interval and priming. Error bars indicate standard error of the mean.

Due to the specificity of the aims of the current experiment, planned comparisons were conducted to determine whether the short lag AR condition and/or long lag AR condition each independently produced positive priming. It was demonstrated that RT in the short lag AR condition was 181ms faster than in the short lag unrelated control condition, $t(44)$ =6.231, $p < 0.01$, 95% CI [122.610, 239.835], $d = 0.93$, indicating a positive priming effect. In comparing the RTs in the long lag unrelated control condition and the long lag AR condition, RT was not significantly different, $t(44) = 0.401$, $p = 0.690$, 95% CI [-38.820, 25.932], $d = 0.06$, demonstrating that at the long lag, there was no evidence of positive priming. Across participants the lag times between prime distractor and coupled probe target words for the long lag AR manipulation ranged from 7.06 – 12.30 minutes ($M = 8.42$ minutes). This was comparable to the lag time in the previous IR experiment ($M = 8.48$ minutes).

Error Analysis

Error rates (presented in Table 2) were similarly analyzed and were greater in the long lag

conditions than the short lag conditions, $F(1, 44) = 23.050$, $p < 0.01$, $\eta^2 = 0.344$. The priming

main effect for error rates was also significant, $F(1, 44) = 4.225$, $p = 0.046$, $\eta^2 = 0.088$

indicating that error rates were significantly greater in the unrelated control conditions

compared to the AR conditions. The lag x priming interaction was not statistically significant,

$F(1, 44) = 0.004$, $p = 0.951$, $\eta^2 < 0.001$. Overall the error rate analyses indicated that a

speed-accuracy trade off does not compromise the priming effects obtained in the response

latency data.

Table 2
Mean Lexical Decision Error percentage for each condition.

	Unrelated Control	Attended Repetition
Short lag	2.78%	1.72%
Long lag	5.07%	4.07%
Total Response Errors	3.03%	

Catch trial analysis

 Analysis of the catch trial results demonstrated that only one out of 45 participants was able

to recall the prime distractor in the catch trial. This was not subjected to further analysis, but

it clearly indicated that there is little evidence of explicit knowledge of the identity of the

prime distractor word. Coincidentally, it was also the case that only one person out of 45 was

able to recall the catch trial distractor in the previous IR experiment. On the subsequent

recognition portion of the catch trial, 11 out of 44 participants were able to correctly choose

the prime distractor among the five options in the catch trial. A binomial test indicated that

the proportion of participants who correctly recognized the prime distractor was no different

than what would be expected by chance (0.20), ($p = 0.254$).

Surface feature analysis

In light of the finding of long lag IR negative priming under identical task conditions in the

previous experiment, the lack of long lag positive priming observed in the current experiment

appears to contradict what would be expected by an episodic retrieval account. Perhaps,

further commonalities between the prime and probe stimulus would be needed for episodic

retrieval to play a role in eliciting the prior encounter with the probe target in the long lag AR

condition. Thus, three separate surface feature analyses were conducted in order to determine

if this might be the case. In each of these analyses, facilitation scores were calculated by

subtracting the AR condition reaction time from the unrelated control condition reaction time.

The first analysis assessed whether the short and long term priming effects differed when the

prime target and probe target were presented both on top or both on bottom of the distractor

(Same) compared to when one was presented on top and the other on the bottom (Different).

It should be noted that for the long lag, the Same condition represents when the prime target

and the probe target 144 trials later were both presented either above or below the distractor.

It would be expected that episodic retrieval would be more likely to occur in the Same

condition where the probe target is in the same vertical spatial position as the prime target.

Facilitation scores were calculated for each of the four conditions; Short Same, Short

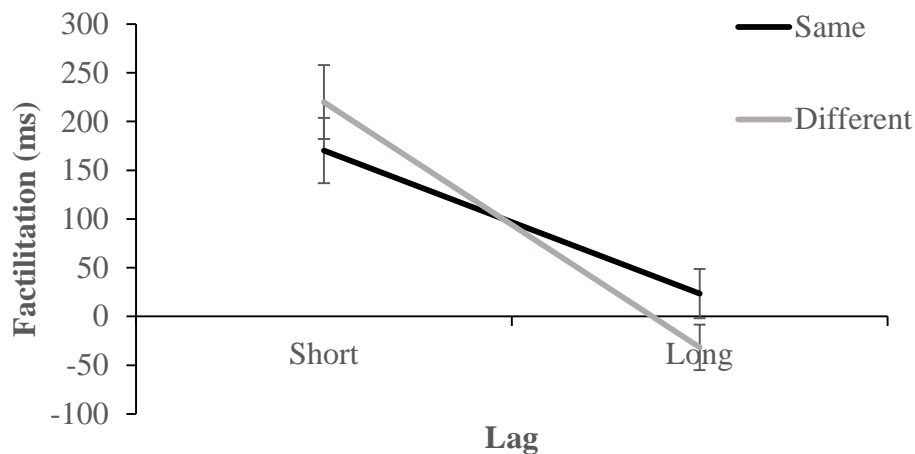Different, Long Same, and Long Different. These are presented in Figure 4.

Figure 4. Prime/Probe Upper or Lower analysis. The above data points represent AR benefits compared to the unrelated control conditions. In the Same condition both the prime and probe targets were presented either above or below the distractor. In the Different condition, the prime target was presented in a different upper/lower position to the probe target. Note: error bars are SEM.

A 2 (lag: short vs. long) x 2 (upper/lower position: same vs. different) repeated measures

analysis of variance confirmed that facilitation was significantly greater in the short lag

conditions compared to the long lag conditions, $F(1, 44) = 30.125$, $p < 0.01$, $\eta^2 = 0.406$.

There was no statistically significant difference between facilitation in the Same conditions

compared to the Different conditions, $F(1, 44) = 0.012$, $p = 0.912$, $\eta^2 < 0.01$. Furthermore,

the interval x positioning interaction was not statistically significant, $F(1, 44) = 3.969$, $p =$

0.05, $\eta^2 = 0.083$ indicating that the effect of the upper/lower positioning compatibility did not

significantly differ between short and long lags.

Because the interaction was close to reaching statistical significance, however, two post hoc

tests were conducted to determine whether either the short or long lag each independently

produced a consistency of positioning effect. It was demonstrated that facilitation in the short

lag Different condition was, on average, 50ms greater than in the short lag Same condition,

$t(44) =1.299$, $p = 0.201$, 95% CI [-126.917, 27.429], $d = 0.19$, indicating no significant effect

of upper/lower positioning. When comparing the long lag Same condition and the long lag

Different condition, facilitation was 55ms greater in the same condition vs. the different

condition and this was also not significantly different, $t(44) = 1.621$, $p = 0.112$, 95% CI [-

13.430, 124.008], $d = 0.24$, confirming no significant effect due to compatibility of upper or

lower positioning.

The second surface feature analysis investigated whether facilitation varied depending on

whether the prime display appeared on the left or right vs. in the centre. As all probe displays

appeared in the centre, when the prime appeared on the left or right it was ascribed the

Different condition, whereas when it appeared in the centre, this was considered the Same

condition. As with the previous analysis, in the long lag condition the prime position of the

paired trial 144 trials previous to the probe was considered. The probe target should be more

likely to elicit the prime target and its "respond" tag when it is presented in the same side to

side spatial position as the prime target. Facilitation scores were calculated by subtracting the

AR condition reaction time from the unrelated control condition reaction time and are
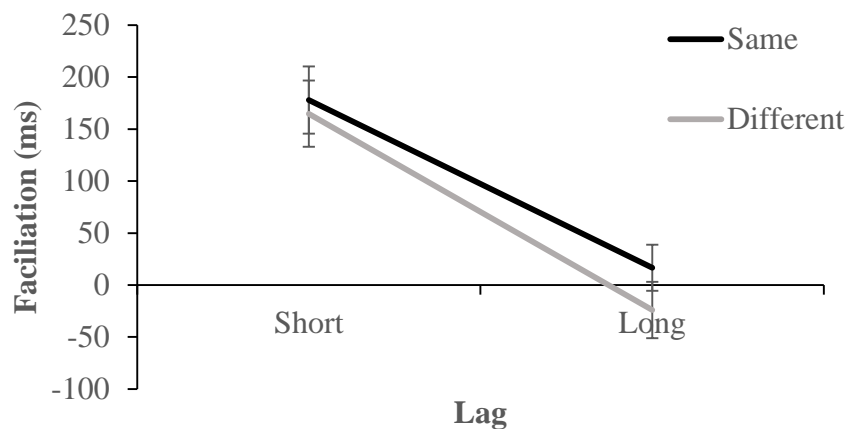
presented in Figure 5.

Figure 5. Prime/Probe Side or Centre analysis. The above data points represent AR benefits compared to the unrelated control conditions. In the Same condition both the prime and probe displays were presented in the centre of the screen. In the Different condition, the prime display was presented either to the left or right of centre and the probe display was presented in the centre. Note: error bars are SEM.

A 2 (lag: short vs. long) x 2 (side/centre position: same vs. different) repeated measures analysis of variance confirmed that facilitation was significantly greater in the short lag conditions compared to the long lag conditions, $F(1, 44) = 24.558$, $p < 0.01$, $\eta^2 = 0.358$. There was no statistically significant difference between facilitation in the Same conditions compared to the Different conditions, $F(1, 44) = 1.418$, $p = 0.240$, $\eta^2 = 0.031$. Furthermore, the lag x positioning interaction was not statistically significant, $F(1, 44) = 0.470$, $p = 0.496$, $\eta^2 = 0.011$ indicating that the effect of the side or centre positioning did not significantly differ between short and long lags.

The final surface feature analysis assessed whether the short and long lag priming effects differed when the episodic context was more similar or dissimilar. The Same condition was defined as the prime and probe displays both appearing in the centre as well as the prime and probe target both appearing either above or both below the distractors. The Different

condition was made up of any prime and probe displays that did not fulfil the criteria for the

Same condition. For the long lags, the relevant prime was the prime that appeared 144 trials

before the probe display. The Same condition should create optimal conditions for inducing

episodic retrieval in the AR conditions as the prime and probe targets would consist not only

of the identical word, but also the fact that those words are appearing in the exact same

spatial location. Facilitation scores for the Same and Different conditions are presented in
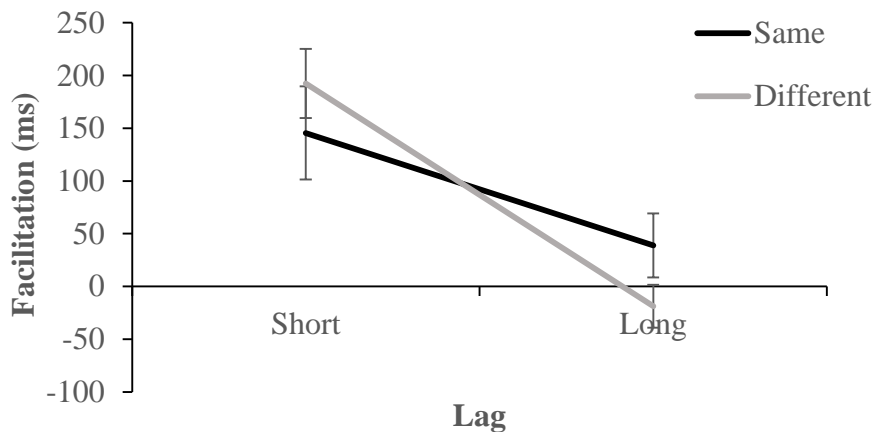
Figure 6.

Figure 6. Prime/Probe Context analysis. The above data points represent AR benefits
compared to the unrelated control conditions. In the Same condition both the prime and
probe displays were presented in the centre of the screen AND the prime and probe targets
both appeared either above or below the distractors. Note: error bars are SEM.

A 2 (lag: short vs. long) x 2 (contextual similarity: same vs. different) repeated measures

analysis of variance confirmed that facilitation was significantly greater in the short lag

conditions compared to the long lag conditions, $F(1, 44) = 16.076$, $p < 0.01$, $\eta^2 = 0.268$.

There was no statistically significant difference between facilitation in the Same conditions

compared to the Different conditions, $F(1, 44) = 0.037$, $p = 0.848$, $\eta^2 = 0.001$. The interval x

context interaction, however, was statistically significant, $F(1, 44) = 4.529$, $p = 0.039$, $\eta^2 = 0.093$ indicating that the effect of Same vs. Different significantly differed between short and long intervals.

To further investigate this interaction, two post hoc tests were conducted to determine whether the short or long lag each independently produced a contextual similarity effect. It was demonstrated that facilitation in the short lag did not significantly differ between the Same vs. Different conditions, $t(44) = 1.192$, $p = 0.20$, 95% CI [-126.256, 32.434], $d = 0.18$, indicating no significant effect of contextual similarity. When comparing the long lag Same condition and the long lag Different condition, there was also no significant difference in facilitation, $t(44) = 1.634$, $p = 0.109$, 95% CI [-13.481, 129.036], $d = 0.24$, again demonstrating no significant effect of contextual similarity.

Discussion

The results demonstrate that repetition priming occurred in the short lag condition, evidenced by a decrease in RTs in the AR condition relative to the unrelated control condition. This finding is consistent with much previous research suggesting that presentation of a stimulus facilitates subsequent processing of that same stimulus. Further, it was demonstrated that this effect failed to persist over the course of eight minutes and 144 intervening trials. As detailed below, and in combination with the results obtained in my Honours' project, these results have implications for the understanding of mechanisms underlying the temporal dimension of priming effects.

Temporal Dimension of Priming

As previously mentioned, my Honours' project last year reported a large negative priming

effect that endured over the course of over eight minutes and as many intervening trials as in

the present experiment. The results from the current experiment showed only a large short lag

AR positive priming effect. Contrary to the results from last year this effect was not evident

in the eight-minute delay condition. The long lag IR effect found last year was, to my

knowledge, the first documented finding of long-term negative priming with word stimuli.

Treisman and DeSchepper (1996), using lags of 100 and 200 intervening trials, failed to find

long-term negative priming with word stimuli selected from a large pool of words, where

words were presented only once except to fulfil the IR manipulation. Their manipulation

used target and distractor words in different colours, whereas the Honours' experiment used

the same font, font size, and colour for target and distractor stimuli. Having targets and

distractors appearing in different colours could lead to a lack of selection difficulty that, in

turn, could extinguish the negative priming effect (Neumann et al., 1999).

Tipper and Milliken (1996) argued that multiple pre-experiment representations of a familiar

distractor stimulus would lead to a failure to find long-term negative priming. Yet in the

Honours' experiment negative priming was found despite the fact that common word stimuli

would carry many pre-experiment representations in memory. This finding is somewhat

problematic for episodic retrieval proponents. From an episodic retrieval perspective, it

could be claimed that the contextual similarities between the prime and probe episodes would

be enough for the prime episode (with its 'do not respond' tag) to be elicited when the probe

episode is presented. Although the change from naming a prime target to making a lexical

decision to a probe target eight minutes later constitutes a large contextual change, there are

also a number of contextual similarities between prime and probe episodes, such as similarity

of size and type of font, two words being presented simultaneously, and the subjects

requirement to always respond to the lowercase and ignore the uppercase. Thus, it could be

argued that these contextual similarities were sufficient for episodic retrieval to occur in the

long lag IR condition of the Honours' experiment.

Previous research suggests that words are able to produce facilitation at lagged intervals.

However, these intervals are much shorter than those used in the current experiment. Among

the longest intervals, Kersteen-Tucker (1991) reported significant facilitation at lags as great

as eight intervening stimuli. Moreover, Bentin and Moscovitch (1988) found that words

produced significant repetition effects at lags of 4 and 15 intervening stimuli and that there

was no difference in the magnitude of these effects.

Conversely, in their follow up experiment, Bentin and Moscovitch (1988) found that this

effect was eliminated under conditions where participants directed their attention only to

superficial features of the words. The authors concluded that these conditions led to the

creation of a weak memory trace at the time of prime processing such that the probe episode

was not sufficient to elicit this trace. Accordingly, it was proposed by both Kersteen-Tucker

(1991) and Bentin and Moscovitch (1988) that episodic retrieval is the underlying mechanism

of facilitation at lagged intervals. It could be claimed that in the current experiment, although

participants were required to read the word aloud, they may not have had adequate time to

access a deeper internal representation of the word and thereby create a robust memory trace

for episodic retrieval to occur 144 trials later. If this held true, however, it would be

improbable that long lag IR negative priming would be found under the same task conditions.

In the long lag IR experiment, the prime distractor was ignored and participants should have

been even less likely to access deeper internal representations of this stimulus than one they

had consciously processed and spoken aloud in the AR condition.

The results of the current experiment are consistent with the idea of Wheeldon and Monsel

(1992) who proposed that facilitation at long intervals is due to a change in the processing

pathway rather than the retrieval of an episodic trace. These authors claimed that it is

unlikely that episodic retrieval would have time to operate in an experiment such as the

current one due to the limited processing time devoted to the prime target. Their experiments

are some of the only available that investigate repetition priming over intervals, with many

intervening trials, more comparable to the present experiment. In their experiments, the prime

presented was either a definition or a word prime. After a delay of 60-120 intervening trials,

a probe appeared in the form of a picture and participants were required to respond by

producing a spoken word. Although significant repetition priming was found at a long lag,

because the task was designed using definitions and pictures, the authors were unsure as to

whether it was the production of the phonological word form alone, or whether it was the

activation of the word's meaning that produced the repetition priming effect.

Consequently, the authors conducted a follow up experiment using homophone pairs where

some pairs were homographic – the words for both meanings have the same spelling (e.g. bat

and bat) and some pairs were heterographic – the words for both meanings have different

spellings (e.g. son or sun). Further, the prime definitions were designed to either induce the

same meaning as the pictured item, or the same word form as the pictured item with an

unrelated meaning. For example, if the probe was a picture of the sun, the two prime

definitions created were "It rises in the east and sets in the west" and "Like father like….". It

was found that facilitation occurred at a lag of 60 – 120 intervening trials but only for probes

that were preceded by a prime definition of the same meaning. There was no facilitation

evident for probe items that were preceded by a prime definition of a different meaning (homophones). It was concluded that prior production of the same phonological word form is inadequate in generating a repetition priming effect over long intervals. In the current experiment, the prime task involved the participants reading aloud the target word. If production of the phonological word form alone is not enough to produce long lag priming effects, it would be expected that there would be no long lag IR evident in the Honours' experiment. An important feature of the explanation provided by Wheeldon and Monsel (1992) is that priming effects over long lags are mediated by how the initial prime is processed. It is suggested that the rehearsal of the link between the phonological word form and its appropriate meaning can lead to facilitation. The initial processing of the prime stimulus used for the long lag priming conditions is very different between the Honours' experiment and the current one. Whilst the current experiment requires the participant to read aloud the prime target, making it consciously accessible, the Honours' experiment requires the participant to ignore the prime distractor and, based on catch trial performance, it can be conjectured that the identity of the distractor is not within conscious awareness. These conditions would not encourage rehearsal of the link between the phonological word form and its meaning. Although their explanation of facilitation effects at long lags are plausible, they do not necessarily explain long lag inhibition effects. Differential processing of the prime stimulus between the AR and IR conditions may determine whether these effects will be evident over large delays. It cannot be assumed that the same mechanisms that underlie long term facilitation also underlie long term inhibition.

The episodic retrieval perspective has a great deal of difficulty accommodating the absence of long lag AR positive priming. If long lag IR negative priming results from the retrieval of the prime distractor with a "do not respond" tag, it would be expected that facilitation should

occur in the long lag AR condition of the current experiment such that the prime target

should be retrieved with a compatible "respond" tag. This did not hold as the results

demonstrate that there is no AR effect evident after the delay. As specified earlier, the

current experiment was designed almost identically to the Honours' experiment in that all

timing and presentation of stimuli, response requirements from the participants, and number

of intervening trials in the delay were identical. Furthermore, the word lists that were used for

the long lag IR manipulation in the Honours' experiment were the same word lists used in the

long lag AR manipulation in the current experiment, such that the probe target words were

identical across the two experiments. Episodic retrieval mechanisms alone thus cannot

explain why there is a clear-cut dissociation between these factors. If anything, episodic

retrieval would predict that it is more likely for long lag AR positive priming to occur than

long lag IR negative priming in these two experiments. The probe target in the long lag AR

condition of the current experiment is identical to the prime target presented earlier and, as

such, this should create the perfect environment for episodic retrieval to occur. The probe

target in the long lag IR condition of the previous experiment, although very similar to the

prime target, differs in that the probe target is presented in lowercase whilst the prime

distractor is presented in uppercase. Collectively, these findings question the foundations of

the episodic retrieval theory. Firstly, it cannot straightforwardly account for the absence of

long lag AR positive priming; and secondly, it cannot account for the presence of long lag IR

negative priming whereby there is even less similarity between the prime and probe contexts

than was the case in the long lag AR condition.

Why then is it the case that long lag IR negative priming can be observed in the absence of

long lag AR positive priming despite the fact that the task seems to be more appropriately

designed to produce long lag AR positive priming than long lag IR negative priming? A

major difference between the IR experiment and the AR experiment is how the initial word

prime is processed. In the IR experiment, the prime word is ignored by the participant and

processed implicitly such that there is no conscious awareness of the prime. In the AR

experiment, the prime word is processed explicitly as participants are speaking the prime

word aloud and hearing themselves say the word. It appears that explicit processing of a

target word is subject to interference not encountered by the implicit processing of an ignored

word. The explicit processing of the prime target in the AR experiment makes it highly

likely that participants could have noticed that the prime target they read aloud was

sometimes immediately presented as the probe target (the short lag AR condition). It is

doubtful that any participant recognized that prime targets sometimes become probe targets

144 trials later (the long lag AR condition). Participants would then expect that if the prime

target word was presented twice, it was done so immediately in the same trial. Accordingly,

after making a lexical decision to the probe target in a given trial, any activation of the prime

target would be considered unnecessary and would likely dissipate, leading to the absence of

an long lag AR positive priming effect. However, in the IR experiment the unconscious

processing of the distractor would make it improbable that participants would recognize the

relationship between the ignored prime distractor and the probe target even within the short

lag condition.

Catch trial Results

The catch trial for the Honours' experiment last year presented only a final prime display,

followed immediately by a screen asking participants if they could recall the prime distractor.

After five seconds, a display of three words of the same length as the prime distractor

appeared on the screen and the participants were instructed to choose which of the three items

was previously presented as the prime distractor. Under these conditions, it was found that

there was a difference between recall and recognition memory in the catch trial. Whilst only

one participant was able to recall the prime distractor in the catch trial when asked,

significantly more than a chance number of participants were able choose the prime distractor

from a list of three words (recognition test). Typically, in negative priming research,

participants are unable to recognize the distractor in catch trials. For example, DeSchepper

and Treisman (1996) presented multiple catch trials throughout their experiment which

involved four shapes being presented on the screen and requesting participants to choose

which one they had seen before. Of these four shapes, one had previously been an ignored

distractor whilst the other three were experimentally novel. Thus participants had a 25%

chance of guessing correctly if there was no explicit recognition of the previously ignored

shape. It was found that correct recognition of ignored shapes averaged 26% which was not

significantly different from chance.   Furthermore, a recent study found that participants

demonstrated intertrial facilitatory priming in the absence of explicit recognition memory for

target identification (Jiang, Shupe, Swallow, & Tan, 2016). The explanation for these

findings was that the surprise memory test used to assess recognition memory may have

disrupted memory for the target item. However, Jiang et al. (2016) also assumed that under

some conditions people retain information about visual attributes of stimuli and this

information may be in the form of an implicit memory trace. Recognition is generally

considered a form of explicit memory that requires conscious recollection (Roediger, 1990).

This being the case, it is surprising that participants in the Honours' experiment were able to

recognize the prime distractor word if it is accepted that no explicit information about the

distractor is stored. If the prime distractor is processed exclusively in the implicit memory

system, explicit recognition should not occur.

However, a study by Johnston, Hawley, and Elliot (1991) demonstrated that perceptual

fluency influenced recognition judgments, but only when there was no explicit memory for

the event. They reported that accurate recognition judgments can be obtained even when

there is no explicit memory for the item. In the Honours' experiment, the three word options

in the recognition test were all vastly different from one another (e.g., NERVE, ALLEY,

CHEST) and began and ended with different letters. It was surmised that participants may

have recognised some distinguishing tick marks from the letters of the prime distractor that

led to guessing the correct recognition word. The catch trial in the current experiment was

therefore redesigned to test the above assumption. Following a typical prime display,

participants were asked if they could recall the prime distractor word. After a period of five

seconds, five words of equal length to the prime distractor word were presented on the

screen. Crucially, all of the words both began and ended with the same letters as the prime

distractor. For example, if the prime distractor was "GUIDE", the five options presented

were: GLARE, GAUGE, GRATE, GUIDE, and GRIPE. Under these new conditions, it was

found that participants were now unable to recognise the prime distractor beyond chance

levels of guessing. This supports the assumption that participants in the Honours' experiment

were somehow benefitting from certain perceptual features of the prime distractor rather than

recognising the word itself and actually had no explicit memory of the prime distractor word.

This is a potentially important observation that should be adapted in future negative priming

experiments that use words are the stimuli under investigation. Failure to do so may lead to

faulty assumptions regarding the degree to which distractor words are explicitly processed.

Surface feature analysis

As previously mentioned, there has been much research on the effects of varying surface

features of stimuli. Instances of processing advantages due to surface feature matches is

consistent with the episodic retrieval framework. Conversely, the absence of such advantages would suggest that something is amiss in the episodic retrieval framework. In the current experiment, not only did a direct copy of an attended prime word fail to elicit its prior encounter, but several other surface feature commonalities failed to produce a long term AR facilitation advantage. Three separate surface feature analyses were conducted. The first analysis investigated cases where the prime and probe displays each had the target word presented on the top or bottom compared to when the vertical position of the target word varied between the prime and the probe. The effects of these two conditions on facilitation were assessed for both short and long lag facilitation and it was found that at both intervals, there was no statistically significant difference between the conditions. Therefore, under both conditions, short lag facilitation was present but there was no long lag facilitation. The second analysis assessed cases where the prime display was presented on the left or right compared to when the prime display was presented in the centre. Notably, the probe display always appeared in the centre. Once again, there was no statistically significant difference between these two conditions. In the remaining analysis, these two parameters were combined such that cases classified as "same" were defined as cases where the prime display was presented in the centre and the target word remained in the same upper or lower position between prime and probe displays. All other cases were considered "different". Under these conditions, it was found that for both same and different cases, facilitation was evident in the short lag condition but not in the long lag condition. Hence, despite these ever-increasing contextual similarity matches in the long lag condition, the episodic retrieval framework finds no support from these additional surface feature analyses.

The results of the current experiment are partially consistent with the research of Manso DeZuniga, Humprheys, and Evett (1990) who used a lexical decision task and varied whether

the probe display immediately followed the prime or whether there was a lag of 15

intervening trials. Unlike the current experiment, significant facilitation was reported over

both short and long intervals. In addition, the authors manipulated whether the prime and

probe components were presented in either hand written or type font. It was found that

holding the surface features constant was beneficial in some conditions but not others. In

particular, in the immediate condition, when the probe targets were handwritten there was a

significant advantage when the prime display was also handwritten. However, this advantage

disappeared when the probe targets were typewritten. There was no effect of type or hand

written stimuli in the long interval conditions. The authors concluded that the effect found in

the immediate condition is most likely due to an advantage of the episodic representation of

the prime display being identical to the probe display. In the long interval condition, they

suggested that over the time interval, the episodic representation of the prime display decays,

or is overwritten, and any advantage of having a similar context between prime and probe

displays disappears. These results are wholly consistent with those of the current experiment

in which all stimuli were typewritten and no advantage was observed by holding the surface

features constant in the immediate condition. In accordance with Manso DeZuniga et als.

conjectures, a substantially larger time interval between prime and probe displays in the

current long interval condition (144 intervening trials compared to 15 intervening trials) it

can be expected that any episodic representation created at the prime display would have

completely decayed at the point that the probe is presented. Even in conditions where the

prime and probe displays were presented in an identical format, no facilitation effect was

evident over the intervening delay in the present experiment.

In the current experiment, orthographic abstract representations likely mediated the

facilitation obtained in the short lag AR condition. Consistent with a study by Bowers (1996)

no difference was found in the level of facilitation in the short lag conditions when the

surface features varied compared to when they were held constant. Bowers (1996) had

participants study words constructed from letters that look similar in upper and lower case

(low shift) vs letters that look different between the cases (high shift). Participants either

studied, and were tested with, words presented in the same case (same) or in different cases

(different). It was found that the level of facilitation did not differ between high shift or low

shift words in the same versus different conditions. Consistent with this, varying the location

(upper or lower and side or centre) of the uppercase and lowercase words between the prime

and probe displays in the current experiment did not affect the level of facilitation. This is

inconsistent with an episodic retrieval perspective where greater facilitation would occur in

situations where the prime and probe contexts are more similar compared to situations where

they are very different.

Conclusion

In conclusion, the current experiment found evidence of AR positive priming at a short lag,

however, it failed to find any facilitation effects at a delay of 144 intervening trials. The lack

of repetition priming at long lags is consistent with previous research suggesting activation of

a word's meaning is necessary to produce a durable, ongoing facilitation effect. This

experiment was specifically designed to investigate long lag repetition priming under

identical conditions to the long lag negative priming found in my 2016 Honours' experiment.

The current results demonstrate that long lag AR positive priming was not obtained under

nearly identical conditions in which long lag IR negative priming was clearly observed.

These results contribute to a better understanding of the mechanisms underlying selective

attention and memory, and question the main tenets of an episodic retrieval perspective of

priming.

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Appendix

Group __1__

Subject Number:_____ Date: _____ Time: _____

Age: Gender:

Recorder Instructions: Please make sure that subject details on this sheet identify the subject data file. **Write down** only **incorrect** words in the space beside the listed word, use a dash (------) to indicate a missed response, leave blank if correct.

- hat
- sign
- rug
- witch
- beach
- toy
- sofa
- consul
- cube
- crater
- wagon
- shorts
- nun
- bee
- limb
- asylum
- youth
- rail
- flea
- grease
- body
- island
- hook
- cow

1. pram
2. box
3. cloud
4. teeth
5. knee
6. model
7. liar
8. sting
9. prison
10. yard
11. spider
12. illness
13. total
14. hamper
15. bird
16. toes
17. tour
18. cab
19. film
20. plant
21. pepper
22. study
23. earth
24. reward
25. menu
26. hump
27. spoon
28. flaw
29. pledge
30. waist
31. hem
32. saliva
33. mother
34. enemy
35. gypsy
36. leaf
37. member
38. context
39. switch
40. start
41. sandal
42. pig
43. bamboo
44. hotel
45. chisel
46. rage
47. engine
48. cellar
49. nose
50. middle
51. powder
52. eject
53. parrot
54. saucepan

55. tree
56. curfew
57. cat
58. glass
59. dam
60. warning
61. sieve
62. yarn
63. plumb
64. heat
65. chest
66. danger
67. odour
68. jingle
69. mildew
70. mouse
71. milk
72. stick
73. core
74. equal
75. orchid
76. fat
77. wolf
78. mug
79. envy
80. axe
81. bore
82. sick
83. skate
84. rubber
85. flag
86. sunk
87. sentence
88. lover
89. germ
90. photo
91. war
92. peg
93. fiddle
94. dame
95. /\ /\ /\ /\
96. air
97. monster
98. request
99. pasture
100. doctor
101. throne
102. deluge
103. rest
104. thigh
105. ladder
106. clock
107. lizard
108. shaver
109. tribe
110. neckband
111. choice
112. honey
113. poem
114. sheep
115. fountain
116. track
117. means
118. martyr
119. feather
120. knob
121. matron
122. letter
123. sugar
124. lounge
125. trash
126. all
127. paving
128. tunic
129. design
130. towel
131. storm
132. skin
133. city
134. advice
135. child
136. usher
137. cannon
138. bear
139. dinner
140. sack
141. fable
142. hair
143. mole
144. monk
145. dealer
146. diver
147. list
148. canyon
149. mob
150. story
151. caddy
152. step
153. bonnet
154. dew

205. chain
206. concert
207. cousin
208. toss
209. smog
210. neck
211. uproar
212. cocoon
213. embassy
214. stair
215. process
216. people
217. saloon
218. scholar
219. trade
220. lump
221. fun
222. card
223. voucher
224. sound
225. square
226. orange
227. hiss
228. refund
229. lunch
230. cigar
231. museum
232. tavern
233. whip
234. abdomen
235. concept
236. husband
237. patent
238. costume
239. sale
240. notice
241. dream
242. vein
243. tourist
244. family
245. mound
246. church
247. method
248. term
249. needle
250. ace
251. yawn
252. mat
253. jigsaw
254. soil

155. mansion
156. chime
157. pillow
158. seal
159. bone
160. vacancy
161. why
162. tar
163. folder
164. lobe
165. number
166. officer
167. rags
168. sail
169. strap
170. wool
171. cheat
172. access
173. eaves
174. glacier
175. title
176. fear
177. puppet
178. twig
179. brook
180. partner
181. lewd
182. heresy
183. wars
184. movie
185. remark
186. shrub
187. blood
188. pie
189. tame
190. landing
191. hand
192. sausage
193. pistol
194. suit
195. trench
196. year
197. streak
198. shot
199. scarf
200. jar
201. surgeon
202. contour
203. bug
204. angel

255. poke
256. clap
257. vent
258. window
259. axle
260. dean
261. zoo
262. crack
263. tiger
264. spot
265. bunk
266. any
267. dough
268. norm
269. harvest
270. element
271. voice
272. toast
273. figure
274. cargo
275. mast
276. deep
277. panel
278. doubt
279. like
280. line
281. load
282. salary
283. brew
284. spark
285. inn
286. career
287. supper
288. repeat
289. audit
290. pop
291. fetch
292. moment
293. bed
294. clerk
295. pour

Catch trial:

Prime: cheese

GUIDE

Recollection: Y/N
Recognition: