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An Examination of Imagined Contexts: The Unreliability of Context-Dependent Memory Effects in Recall

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An Examination of Imagined Contexts: The Unreliability

of Context-Dependent Memory Effects in Recall

by

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Abstract

It is generally accepted that the environmental context present during memory encoding serves as an effective cue for recall if reinstated during retrieval. Participants who perform a free recall test in the same context as that during which they learned a set of words, often remember more words than participants who experience a context mismatch from encoding to retrieval. This is referred to as the context-dependent memory effect and forgetting due to a change in context is referred to as context-dependent forgetting. Recent evidence suggests that contexts need not always be physical but can be mentally generated or imagined and still serve to produce a context-dependent memory effect. That is, participants who recall information in a reinstated imagined context remember more words than those that do not reinstate the imagined context at recall, even when in a physically different context. Four experiments were conducted in an attempt to replicate context-dependent memory effects using imagined contexts and mental reinstatement. Participants learned a list of words in one physical context (room) followed by a free recall test in either the same or different room. Some participants were given instructions to imagine a context (one from a picture or a self-relevant context) during encoding and to later reinstate this imagined context at recall while in a physically different room. Results showed that not only was there no difference in number of words recalled among groups who imagined a context and those that did not, but that there was no effect of physical context as well. This set of studies demonstrates that context effects, whether physical or mentally generated, are not as robust as currently conceptualized.

Keywords: imagination; memory; context reinstatement; recall; forgetting; self

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Chapter 1: Introduction

One does not need to have a deficit in memory in order to experience disruptions of recall. We struggle many times a day to recall information we need; where items were placed, what we ate for breakfast, even what we were just doing a moment ago. What does it take to reconstruct a memory accurately? Are we aware of the factors that lead to the encoding of that information in the first place? Is there a way to protect ourselves against forgetting?

Memories are encoded into a trace along with context, a multi-faceted factor that may determine what and how well we remember something. Context has long been thought to be an important cue for memory, but some evidence suggests that contexts effects may not always be reliable. Exploring the criticality of context-dependent memory is necessary if we wish to appreciate why we remember, and often more pertinent, why we forget.

Context-dependent memory

Context-dependent memory is the phenomenon whereby information learned in one context (typically the physical environment) is better remembered in that same context and is more likely forgotten in a different one. We have probably experienced this in our daily lives – much to our frustration – where we think about getting something in our house, say upstairs, repeating it several times to ourselves before ascending, and once ascended immediately forget what it was that we were supposed to retrieve. This is probably due to the fact that we were trying to remember something in a different context than where we first learned it, with the bottom of the stairs being a context that does match the context of the top of the stairs. But when we return to the bottom of the stairs, the memory suddenly comes to mind, as now we have returned to the original context, and we question how we could be so forgetful in a matter of seconds.

Context can be conceived of as more than just an encoding environment or location and can affect more than just recall of basic facts or items. For example, environmental context has been shown to affect memory for performed actions, where words that were physically performed were better remembered in the original context where they were acted out than in a different context (Sahakyan, 2010). Context also has been shown to affect memory for words after a change in physiological state due to a drug (Eich, Weingartner, Stillman, & Gillin, 1975) and even visual recognition and recall of symbols and faces due to a change in mood (Robinson & Rollings, 2011). Thus, physiological or emotional state may also serve as an important internal context for memory besides that of the external environment. Carr (1925) shares an amusing story where physiological state was indeed a necessary context: "There is the old story of the Irish porter who misplaced a package while drunk and was able to recall its location during a subsequent period of drunkenness" (p. 252).

These accounts of memory being affected by a change in context suggest that the item is somehow integrated with the context. When we encode an item in memory, it becomes mentally associated with the context and recall is best when the association is strong, direct and numerous (Carr, 1925). This association is dependent on the context however, and without its presence, forgetting is more likely. Forgetting due to a change of context is referred to as context-dependent forgetting, where memory suffers from the mismatch of original encoding context and later retrieval context. Smith (1979) notes that being provided with the same learning context will activate the original contextual representations which in turn will provide access to original mental representations of the associated material and thus facilitate memory. This is known as the reinstatement paradigm and is a common way researchers study context-dependent memory. In these studies, a participant learns information in one context and when later tested in the same context, have better memory than individuals who were tested in a different context. Reinstating the original learning context at test maintains the contextual associations necessary to probe memory. In a classic study by Godden and Baddeley (1975), they show the importance of environmental context and forgetting that occurs when environments change from encoding to recall.

Godden and Baddeley (1975) demonstrated that context effects can be elicited with free recall in two natural environments, on land and underwater. They tested groups of divers in these two environments for recall of a list of words that were either learned on land or in the water. Divers that were tested in the same environment where they first learned the words were able to recall more words than divers tested in an environment differing from the original encoding context. Thus, the change in context from encoding to test hindered recall and shows that maintaining the same context is beneficial for free recall of words.

This study seems to clearly demonstrate context effects, albeit in two outdoor environments that we may not encounter in our daily lives. Smith, Glenberg, and Bjork (1978) showed that the same effect can be replicated in an indoor context, more specifically a school setting. They had participants study a list of word pairs in one room and then complete a cued-recall test in either the same or different room two days later. Participants who performed the recall task in the same room where they initially studied the word pairs recalled more words than those who changed to a different room. In fact, context effects can be elicited by an even simpler method than moving large distances between land and water or classroom and classroom.

Radvansky and Copeland (2006) showed that by simply walking through a doorway, individuals displayed worse memory and greater errors for items with which they had just interacted. They attribute this to the *location updating effect* whereby the mental situation model that helps us to understand relationships between objects and the environment, is disrupted by moving through doorways (Radvansky, Krawietz, & Tamplin, 2011). While navigating through a virtual indoor environment, participants were instructed to carry an object, or place an object on a table, and then either move through a doorway or continue walking forward in the room. They were then given a recognition test for the object they had just interacted with. An increase in reaction time and a greater number of identification errors were made in groups that went through doorways into a different room and experienced a spatial shift (Radvansky & Copeland, 2006). It is possible that this is due to the differing contexts experienced between the two sides of the door, and that the shift in context caused a disruption in the associations between the object and its relevant environment.

While the above focuses on more of a source-monitoring perspective (Johnson, Hashtroudi, & Lindsay, 1993), context-dependent memory is usually thought to be cue driven and abiding by the encoding specificity principle (Tulving & Thomson, 1973). Source monitoring – remembering the origin of a memory – involves retrieving many details, one of which may be contextual information. Having to constantly update a mental situation model in order to remember the interaction with an object as one passes through doors utilizes source monitoring, with an aspect of that source possibly being the environmental context.

Participants need to be aware of whether they had picked up or placed down an object, as well as where in space they were when presented with the memory test, and thus be constantly aware of the source of their memory before making a decision (Radvansky & Copeland, 2006).

Retrieval cues on the other hand are a direct link to the memory event, and may also be contextual by nature. According to the encoding specificity principle, the retrieval of an item depends on the similarity between the encoding and retrieval situations, in that the match between a cue present at encoding and retrieval will elicit the appropriate memory (Tulving & Thomson, 1973). This was indeed found when participants learned a list of words each associated with a word cue, and these cues were again present during recall (Tulving & Osler, 1968). Participants recalled more words when the cue was present during both encoding and retrieval, and this level of recall was more than when the retrieval cue was absent, a different cue was present, or a combination of the original cue and different cue were present at recall instead. The initial cue was the most effective cue as it matched both the situation at encoding and retrieval and was best able aid memory of the item.

While Tulving and Thomson (1973) demonstrate that memory subscribes to the encoding specificity principle, they also note the effectiveness of different types of retrieval cues in memory. They find that memories are best elicited by reinstated input cues, or those that were present along with the item during encoding, rather than associates (similar cues) or copies of the target word (Thomson & Tulving, 1970; Tulving & Thomson, 1973). Participants were cued by words associated with the initial cue or literal copies of the target words (that participants generated themselves in a free association task with the cue words before test) and neither of these proved as effective as the original input cue provided by the researchers. This surprisingly demonstrates that even though participants can recognize and are aware of the target words (after all they generated these themselves!) they can only be accurately recalled when the solitary initial cue is present (Tulving & Thomson, 1973). It seems that these input cues are more similar to the initial encoding situation, or *cognitive environment* present during the encoding process than anything else, and are a necessary component for retrieval. Therefore, if an environmental context were the same as that during input or encoding, and it was reinstated during retrieval, then it would serve as an effective input cue with which to revive the corresponding cognitive environment and facilitate memory. In this way, environmental context can act as an effective cue.

The nature of the environmental context has also been conceptualized as having different forms. One distinction, whether the context is incidental or intentional refers to the way the context is encoded. One may encode the context without conscious effort (incidental) or the context may be intentional or consciously associated with the to-be-remembered item (Smith & Vela, 2001). Traditionally, environmental contexts are encoded incidentally, whereby participants in a study are focusing attention on the target information and not attending to the learning or test contexts while performing tasks.

Contexts can also be referred to as extrinsic or intrinsic. Extrinsic contexts are considered independent from the items, as compared with intrinsic contexts which are associated directly with stimuli (Hewitt, 1977; as cited in Godden & Baddeley, 1980). Intrinsic contexts may be properties of the stimuli themselves, for example, the font (e.g., size, typeface, colour) of list words. Extrinsic contexts also take different forms. Maren, Phan, and Liberzon (2013) note that extrinsic contexts may be cognitive (e.g., expectations that may influence encoding and retrieval), interoceptive (e.g., hormonal and physiological states), environmental (spatial), temporal, or social and cultural. While intrinsic contexts are inevitably processed during encoding, and extrinsic contexts seem supplementary to the items encoded, it is evident that both are relevant in context-dependent memory (Godden & Baddeley, 1980).

Lastly, context can be considered global or local, in reference to the number of items they are associated with (Glenberg, 1979). Global contexts, are considered those that are less specific and are connected with many items, such as a room which contains various items, furniture, and equipment that is associated with a list of words. Local contexts are more unique; for example, if context were word colour, each word may be associated with a different colour of text. Local and global contexts have been shown to influence recognition memory in different ways, with local context affecting recognition memory more than global context (Dalton, 1991). In fact, type of context seems to play a role in distinguishing between the presence or absence of context effects depending on the type of memory test.

Recall and Recognition

Seeing that context effects are generally robust, and their impact depends on a variety of factors regarding the manipulation of type of context (Smith & Vela, 2001), it should be noted that these results, at an experimental level, differ with respect to the type of memory test. When examining context effects, it has been found that they are much more robust for tests of recall than tests of recognition (Smith, 1988). Smith and Vela (2001) predicted that free recall tests should be the most affected by context, followed by cued-recall and recognition tests, as these latter tests rely more on non-environmental cues. For example, in cued-recall and recognition tests, experimenters provide cues at test (the retrieval cue and the item itself, respectively) that make the use of environmental context cues less likely. The presence of the target word itself in recognition tests serves as a more effective cue than environmental context cues, thus making environmental context unnecessary (Brown, 1976). In recall tests on the other hand, no such cues are provided during test, which increases participant's reliance on other effective cues, one of which would likely be the environmental context.

Perhaps the clearest distinction between recall and recognition was found in a pair of studies by Godden and Baddeley (1975, 1980). As mentioned previously, in their first study they had divers learn a list of words on land or under water and then complete a recall test in either of these environments. They found a reliable effect of context, in that divers recalling words in the same context where they were learned remembered more words (Godden & Baddeley, 1975). They then replicated the study using a recognition test instead of a recall test and found that there was no difference in number of words remembered across groups (Godden & Baddeley, 1980). That is, divers recognized the same number of words regardless of match or mismatch of learning and testing contexts. They concluded that this difference is due to the opposing effect of environmental context on memory tests, that it is important in recall but not in recognition. They suggest that although intrinsic context is important for both recall and recognition, extrinsic context is not necessary for recognition as it does not encourage participants to use previous internal associations as in recall. Other studies have also shown that even when context affects recall, the same manipulations do not show any difference for recognition (Smith et al., 1978; Smith, 1982; Fernandez & Glenberg, 1985).

Whereas context effects are more difficult to elicit in recognition tests, it has been demonstrated that recall is more reliably affected, whether learning occurs in one room or multiple rooms (Smith, 1979; Smith et al., 1978) and with recall improving as the number of rooms increases (Smith, 1982; Smith, 1984). This multiple room paradigm works by introducing multiple, same-length word lists which are each leaned in a different room, and participants are asked to recall all lists of words in a different room. Participants usually recall more words overall as the number of rooms and corresponding lists increases. For example, a participant who learned one list of words in one room would recall less words than a participant who learned two lists in two rooms or four lists in four rooms.

This highlights the dependence of recall on environmental cues. The multiple room manipulation suggests that each room serves as a different environmental cue or set of cues with which participants can use to organize their memory of the various lists. At test, these multiple cues are available for participants to generate and use to aid recall, suggesting that the more cues are available, the more item associations can be made, and later utilized. This may overcome the issue of cue overload (Watkins & Watkins, 1975) which is where a cue becomes associated with too many items and becomes no longer effective. If the opposite occurs, where items are associated with several cues instead, this may give the participant more possibilities to recover information (Smith, 1984).

However, it should be noted that the beneficial effect of multiple rooms disappears when using the reinstatement paradigm, indicating that increasing the number of cues relative to number of items may not hold in all circumstances. In a study where participants were told to learn three different word lists in three rooms, or to learn the three lists in one room, when they returned to the same context where learning took place, context effects (or better recall in the same environment) were only found for participants who learned the lists in the single room (Smith, 1982; Smith, 1984). Increasing the number of environmental context cues (by increasing the number of learning rooms) made no difference whether participants were in one of the learning environments (same context) or a different context, demonstrating that having more input rooms or environmental cues does not necessarily improve number of words recalled. Additionally, multiple rooms and reinstatement have not been shown to support an effect of context on recognition (Smith, 1982; Murnane & Phelps, 1993).

The general idea is that environmental context affects recall but leaves recognition unaffected. The nature of encoding and retrieval in tests of recognition suggests that it is more sensitive to a change in local, intrinsic, or intentional context instead. Nevertheless, some attempts to find an effect of context, even when items were integrated or intentionally associated with the environmental context have not been successful (Eich, 1985). For example, Eich (1985) had participants associate words with specific objects in a room, in a manner similar to the method of loci. The method of loci is an old mnemonic first used by ancient Greek and Roman speakers to remember long passages of prose. While learning, an individual would associate passages with specific features of a location, and when needing to recite the information later on, would imagine themselves back in that location. They may 'walk' back through the environment, for example a street setting, and as they pass each element, say a house or a window, would recall each set of information associated with each element (Luria, 1968). Eich (1985) found that participants who used this technique during encoding and were later tested for recall in the same or different room, experienced context effects and recalled overall more words than those that did not link words to the environment. However the same was not found for recognition. Context did not affect recognition even when the items were integrated with the context, and in fact, isolated items, or those that were not integrated with objects in the environment were remembered slightly better than integrated items. This puzzling effect demonstrates the difficulty in finding context effects in recognition tests.

The reliance of memory on global environmental context has been manipulated in recognition studies to identify why individuals do not seem to benefit from this type of environmental information. Smith (1986) demonstrated that recognition can benefit from global environmental cues if other, more local, cues are supressed. Participants were directed to complete a short term memory task (shallow encoding) or long term memory task (deep encoding) prior to the recognition test in an attempt to influence the following encoding of item and environmental contextual information. It was assumed that shallow encoding would increase the need to rely on global environmental context cues whereas the associations created from deeper encoding would suppress context effects, being useful cues in and of themselves. In the short term memory task, participants were presented with ten sets each consisting of five words and were required to complete a recall test after every set. Participants were unaware there would be another memory (recognition) test later on. Long term memory tasks were identical to the short term task but included instructions to memorize the words for a later memory test.

It was found that participants in the same context condition made fewer recognition errors as compared to those in the different context condition following the short term memory task (Smith, 1986). Thus, the global environmental context can be a useful cue if other more specific (local) cues are not available or supressed. This concept, referred to as outshining (Smith & Vela, 2001) seems to be an important factor influencing the absence of context effects in recognition studies. Environmental context cues can be outshone at retrieval by other, more salient cues, such as cues that have been repeated, are less overloaded, or those that are more deeply processed (Smith, 1988). This may be one reason why context effects are seen less in recognition studies, as recognition relies on non-environmental cues and other associations created during encoding or elicited during test.

Where context effects for recognition have been found however, the approach to studying recognition has focused more on matching context and item associations from encoding at test through reinstatement, and determining when there is context-dependent discrimination rather than context-dependent recognition. Murnane, Phelps, and Malmberg (1999) developed the ICE (item, context, and ensemble) theory where item is the to-be-remembered item, context is contextual and peripheral information, and ensemble is the association of item and context. They determined that matching contextual information from encoding at test will only be enough to elicit context-dependent recognition, which is when there is an increase in both hit rate and false alarm rate to an old stimulus, and thus no difference in discrimination between targets and distractors.

Participants in a recognition test usually respond *old* or *new* to a stimulus presented within a context at test, indicating if they remember the item (*old*) or if it is an item that was never presented at study (*new*). Context-dependent recognition has been found in participants who viewed words presented in different contexts, whether that be through the manipulation of colours, word position, or photographs of scenes, and were given an old-new recognition test (Murnane & Phelps, 1994; Hockley, 2008). Participants viewed test items in either old (same) contexts, different or rearranged old contexts, or an entirely new context, and it was found that while there was a difference in hit rate and false alarm rate for the old and different or rearranged old contexts as compared to new contexts, there was no difference between old and different or rearranged old contexts. Technically, the different or rearranged old contexts are new contexts, in that they have never been associated with the correct test items before, however participants still responded to them in the same way as they responded to original old items. They were not able to clearly discriminate between old and new items. According to ICE, ensemble information was not elicited or even created in the first place, that is, participants did not create an association with the context and the item, and thus only context-dependent recognition, but not discrimination, occurred.

Conversely, context-dependent discrimination, when there is a measure of discrimination (*d'*) between targets (correct items) and distractors, has been found when there is a manipulation of rich or meaningful contexts (Murnane et al., 1999). Meaningful contexts are those that encourage participants to create ensemble information through the association of the item with the context. Murnane et al. (1999) used the computer to present words on top of various pictures which served as rich contexts. Words were imbedded in pictures where individuals would normally expect them to appear, such as on a television screen, airplane banner or a classroom chalkboard. After giving participants an old-new recognition test in the same or different context, they found not only an increase in hit rate and false alarm rate (context-dependent recognition) but also an effect of *d'* indicating that ensemble information had been created and used to increase participant's discrimination between old and new items.

However, this increase in discrimination using meaningful contexts has not always been found (Hockley, 2008). It seems that participants may not always spontaneously encode ensemble information but must be directed to use contextual information before any change in discrimination is found. In the experiments by Murnane et al. (1999) and Hockley (2008) where context-dependent discrimination was found, this was under the circumstances where participants were instructed to make use of the context present with the item during learning. If participants are directed to notice and incorporate contextual information during learning, they may be more likely to generate these cues at test (Smith, 1988). For example, context effects were only found when participants were explicitly instructed at study to link the environmental context with the study item (Eich, 1985). Other studies have since expanded upon the use of meaningful stimuli and directed association, finding that context-dependent discrimination can be found with face and context picture pairs tested in same or different contexts (Gruppuso, Lindsay, & Masson, 2007), and especially with famous (celebrity) faces which are more meaningful to participants and more likely to be bound to an associated context (Reder et al., 2013).

In trying to make sense of the varying results regarding recall and recognition, Smith and Vela (2001) conducted a meta-analysis to determine when incidental, extrinsic, and global environmental contexts were and were not important. They looked at 75 studies conducted from 1935 to 1997, and calculated 93 effect sizes. It was revealed that context had a reliable effect on memory (d = .28), but that there was no difference for type of test (free recall, cued recall, recognition) which is seemingly counterintuitive. However, at the level of individual experiments, it seems that context effects have been found for recall tests more often than for recognition tests. The authors mention this meta-analysis only gives an organized post-hoc review of conflicting results but cannot replace the careful methodology of experiments in which more work needs to be done to determine when context is and is not influential to memory.

An Application of Context Reinstatement

It has been established that context change seems to affect memory negatively for the most part, and the effects seem to be mitigated when the original cue or encoding context is physically reinstated. The benefits of context reinstatement are apparent not only in research, but can be extended in application to the real world. In a handbook by Fisher & Geiselman (1992) they outline techniques for police or investigator usage when conducting interviews with eyewitnesses of crimes or certain events. Their techniques are based on an empirically tested method called the *cognitive interview*. The cognitive interview focuses on helping eyewitnesses to increase the amount of relevant and correct information supplied to the interviewer. The interview is based on a central idea in memory whereby a memory trace is composed of many features and by increasing the overlap among features from encoding and later in recall, this will improve the amount of information able to be remembered (Geiselman, Fisher, MacKinnon, & Holland, 1986). Four techniques are applied in the interview in order to assist eyewitnesses:

(1) Mental reinstatement of the environment and personal interpretations (including physical, emotional, and physiological contexts) of the crime scene

(2) Complete reporting of all information, even if information seems trivial

(3) Recounting events in a variety of orders and,

(4) Recounting events from a variety of perspectives

Of these, mental reinstatement is the first technique used, and rightly so, as it sets the stage the other mnemonic retrieval techniques. Seeing as during a crime the eyewitness may not be actively encoding environmental information (due to the emotional charge associated with the whirlwind nature of events, as is possible with witnessing any crime), using the cognitive interview (including mental reinstatement) at retrieval is all the more important to implement in order that correct information is recalled (Geiselman, Fisher, MacKinnon, & Holland, 1985). Furthermore, physical reinstatement may not be possible as environments may have changed from the original state of the crime to visitation, making mental reinstatement a convenient and practical tool for investigators. Witnesses are guided by interviewers to simply reconstruct the crime scene in their mind in order to access associated information.

In a series of studies, the cognitive interview was shown to elicit a greater amount of correct information from eyewitnesses through recall, while eliciting no more incorrect nor confabulated information in comparison to a standard police interview (Geiselman et al., 1986; Fisher, Geiselman, & Amador, 1989; Aschermann, Mantwill, & Köhnken, 1991) or an interview conducted under hypnosis (Geiselman et al., 1985). This not only applied to the students in these laboratory studies who viewed videos of simulated crimes in the classroom, but to the real world as well. Fisher et al. (1989) had police detectives conduct interviews with actual victims and eyewitnesses of crimes before and after being trained on use of the cognitive interview, and found that compared to detectives that were untrained, the trained detectives were able to elicit 63% more correct information from the participants. Therefore, the use of the cognitive interview seems to be an excellent tool for the police force in extracting critical information from eyewitnesses regarding crimes.

Since the cognitive interview in its entirety has shown to be useful, we can consider the contribution of each of the four techniques. In order to identify the effect of mental reinstatement, another study was done to test the underlying principle that increasing the feature overlap between encoding and retrieval should improve memory. Testing the first two techniques (mental reinstatement and reporting all information), Geiselman et al. (1986) showed that although using all four techniques of the cognitive interview was the most successful in eliciting more information, mental reinstatement and reporting all details elicited more correct information than for participants who were not given such instructions. Overall, seeing that the physical context of the crime is difficult (and may even be impossible) to recreate at the time of retrieval, mental reinstatement takes precedence as a relevant memory-enhancing technique. Fisher and Geiselman (1992) note the influence of multiple types of contexts on memory by stating "…memory of an event is greatly influenced by how many of the [eyewitness'] original thought patterns, emotional reactions, physiological state, and the physical environment can be recreated at the time of the interview" (p. 90), with the techniques employed by the cognitive interview serving to increase the amount of relevant information retrieved by eyewitnesses, and with mental reinstatement serving an integral role.

Imagination and Mental Reinstatement

Context reinstatement serves as an important way to reduce context-dependent forgetting, by reinstating original context cues from encoding at test. Mental context reinstatement then, through imagination, may be more convenient and just as effective in protecting against context-dependent forgetting. Noting the importance of post-event variables in memory and their relative ease of manipulation as compared to encoding-based manipulations in eyewitness testimony, Krafka & Penrod (1985) also discovered support for mental reinstatement as a useful method to enhance recognition memory. Using a natural shopping store environment, they had store clerks identify a supposed suspect they had previously interacted with from a lineup of photos. Clerks were instructed to mentally reinstate the context at the time of their interaction with the suspect and were provided with physical cues (copy of the suspect's non-photo identification) to help them make a decision. Clerks who were given a chance to mentally reinstate the relevant context made more correct identifications and less errors than those that did not imagine anything. In a similar study, where participants witnessed an act of vandalism, those given a chance to mentally reinstate the context through a guided memory reinstatement instruction also made more correct identifications of the suspect from a lineup than those participants who received no instruction (Malpass & Devine, 1981). Whether participants mostly generated the reinstated context themselves from their own memory and a few cues or are provided with detailed instruction, mental generation of context seems not only to improve recognition accuracy, but is reflected in the strength of confidence ratings provided by participants (Malpass & Devine, 1981; Krafka & Penrod, 1985). The usage of mental reinstatement as an ecologically sound method to aid eyewitnesses, adds to previous studies that attempted to reduce context-dependent forgetting in the real world.

For accurate eyewitness testimony, inspiration to utilize mental reinstatement as an effective technique to elicit information during test or interview was drawn from earlier laboratory studies that examined context reinstatement in classrooms. Noting that context effects occurred when participants changed rooms between learning and test, Smith (1979) wondered why participants did not spontaneously reinstate contextual information when they experienced a shift in context. He predicted that participants who changed to a different context (DC) and participants that stayed in the same context (SC) were both capable of using mental reinstatement of the learning context, however SC participants were more likely to do this than DC participants. Smith (1979, 1984) simply gave the instruction to DC groups to remember their previous learning environment and found that their level of recall was comparable to that of the SC group. Thus, the physical context is not always necessary for reinstatement of the environmental context.

In a different manipulation of mental reinstatement of environmental context, some studies have looked towards imagination of a context as a pre-emptive strategy to reduce context-dependent forgetting. The technique of *preinstatement* has been demonstrated in some studies as a way to reduce context-dependent forgetting by having participants imagine their future testing environment (Brinegar, Lehman, & Malmberg, 2013). These researchers familiarized participants with two physical contexts (an indoor room and outdoor space), one of which would be a learning environment and one that would be a test environment. While in the learning environment, participants were instructed to imagine themselves within the other environment (future test location) and learn a list of words. When they eventually changed to the test environment, this preinstatement group of participants experienced greater recall for list words than groups who were not given a preinstatement instruction and changed contexts, or who had remained in the same context throughout the experiment (Brinegar et al., 2013). Therefore, although preinstatement groups changed physical contexts and would be expected to suffer context-dependent forgetting, their memory was aided by physical cues from the testing context that matched mental cues from the preinstated context. Imagined cues used during preinstatement would have formed associations with test words, and would benefit from a later context match during test, thus negating the effect of physical context change.

This interesting and protective quality of imagined contexts had also been demonstrated in a study by Masicampo and Sahakyan (2014). Also using mental context generation, they implicate that simply generating and imagining a context which is different than the present environment, may in itself be beneficial to memory. That is, the context doesn't necessarily need to be preinstated or be familiar to the participant beforehand, but can be any context as long as mental effort is maintained during encoding to associate the context with to-be-remembered items.

Masicampo and Sahakyan (2014) had participants learn a list of words in a context A while imagining themselves in context A, context B (a previously visited environment) or context A' (a self-generated, transformed context A). These contexts were physical indoor or outdoor locations, and A' was created by asking participants to imagine snow falling from the sky in the learning room. They were later tested in environment A, B, or C (a new environment). Results indicated that participants who imagined context B or A' during encoding later recalled more words (regardless of their testing environment) than those who imagined context A during encoding. It seems that imagining context A while being physically in context A was not beneficial and perhaps redundant, possibly due to the poverty of differences or distinctness in cues available to organize information, as suggested by the benefits of encoding in multiple rooms (Smith, 1984).

Preinstatement in this case (imagining context B, then testing in context B) demonstrated the highest level of recall, due to the fact that cues generated early on were later matched during test. Masicampo and Sahakyan (2014) propose the *facilitated-reinstatement hypothesis*: that an imagined context may protect against forgetting regardless of the actual testing environment. Therefore, imagined contexts are akin to a portable form of protection that can be brought into any environment in order to protect against forgetting, as long as they are associated with the items during encoding and later made available during test. It seems to be the case that researchers are interested in discovering ways to make the environmental context salient enough that participants are more likely to spontaneously reinstate it during test, such as through preinstatement, and in this way context can serve as an effective and self-generated cue.

Self-relevant Imagined Contexts

Seeing the possible benefits of imagined contexts as a way to protect against context-dependent forgetting, we may wonder how to increase the power of this effect. What types or features of imagined contexts make them salient and effective? We have seen previously that meaningful contexts may be more likely to become imbedded into a memory trace as ensemble information, thus producing context-dependent discrimination in recognition memory tests (Murnane et al., 1999). Can such a distinction be made with mentally reinstated or imagined contexts?

Using the strategy of preinstatement of a previously visited physical environment (Brinegar et al., 2013) and even the generation of a modified or transformed current physical context (Masicampo & Sahakyan, 2014) seem to benefit recall during context change. Would the same be true of a purely original imagined context? If participants were given a picture of an environment or given instructions to generate their own context, perhaps these types of contexts would be more effective than those based on a current or previously visited physical context. Some types of contexts may be easier to generate than others, and it is worth looking into what makes a context effective as a reinstatement tool.

In the following experiments presented in this paper, we initially suggest that *self-relevant imagined contexts* may be beneficial in protecting against context-dependent forgetting. A self-relevant context is one that participants find personal meaning in and would likely associate with strong emotions or a particular vividness. These contexts may be environments or places they visit frequently (e.g., a room in their house) or somewhere they find particularly engaging or pleasant to reminisce about (e.g., a vacation spot). Self-relevant contexts may have an advantage over newly visited physical contexts for a few reasons.

Masicampo and Sahakyan (2014) note that in their transformed imagined condition (context A') where participants imagined context A modified to pretend snow was falling from the ceiling, participants had worse recall than the other imagined situations (context B). This may have been due to the fact that context B was more familiar to participants (having recently visited this location prior to encoding). Self-relevant contexts on the other hand may be something participants are more familiar with than a location they only visit once in the span of an experiment. It may also be likely that participants could construct these imagined contexts with less effort and more detail if they are familiar with them instead of having to expend effort to recall aspects of an unfamiliar room or location. Smith (1979) demonstrated that simply providing instructions to mentally reinstate the learning context to participants who changed contexts improved their level of recall, in effect creating a greater ease to which participants could recall information through the use of context cues. Cues that are easier to utilize may also be spontaneously brought forward during test. Therefore, if participants are asked to generate a self-relevant context themselves, it may be easier to spontaneously use to aid recall.

The Underlying Brain Network for Contextual Memory, Imagination, and the Self

Evidence from neuropsychological and neuroimaging studies also show there may be a connection between context-dependent memory and self-relevant imagination. Common areas in the brain that are activated for context-dependent memory, imagination and self-related information may indicate a role for their combination in promoting protection against context-dependent forgetting.

Neuroscience of context effects

Considering episodic memory, the hippocampus and the medial temporal lobes (MTL) seem to be the areas most implicated in context-dependent memory. The role of the hippocampus in episodic memory is famously demonstrated with the patient HM who underwent bilateral hippocampal removal due to enduring seizures (Scoville & Milner, 1957). Due to this surgery, HM had impaired episodic memory and could no longer integrate the spatial and temporal context of occurring events into a coherent memory, which is the essence of episodic memory itself (Tulving, 1983). Due to the spatio-temporal nature of episodic memory, many studies have implicated the hippocampus in encoding spatial relationships while integrating temporal information from the frontal lobes (for a review, see Burgess, Maguire, and O'Keefe 2002). More specifically, the right hippocampus is shown to have more of a role in spatial memory while the left hippocampus facilitates context-dependent memory.

In a study by Burgess, Maguire, Spiers, and O’Keefe (2001) using virtual reality and functional magnetic resonance imaging (fMRI), participants were required to navigate through a virtual town and interact with two different characters. Each of the characters were in a different location and each gave the participant a set of objects. Participants were later tested for their memory regarding one of the objects received, the place where the object was received, and the person the object was received from in a forced choice test. Critically, these questions were asked as the participant approached one of the characters in one of the initial locations and thus represent questions using information about previous spatial contexts. Burgess et al. (2001) found that there was frontal, medial parietal and medial temporal activation for the spatial context tasks. They state that their results support other studies, more specifically regarding the hippocampus and the lateralization of function within this structure. These results are supported by a study using patients with either left or right temporal lobectomies which found that right temporal lobectomy patients had difficulty with spatial tasks (i.e., navigation of the virtual town) whereas left temporal lobectomy patients had difficulty with tasks favouring context-dependent information (i.e., questions about where and from whom the object was received) (Spiers et al., 2001). Therefore, the hippocampus not only processes spatial information but context-dependent information, at least when referring to the environmental context.

In terms of other types of contextual information, the hippocampus has also been shown to have a role in contextual fear conditioning. Fear conditioning is a form of classical conditioning in which a fear memory and subsequent response (conditioned response; CR) is created by repeatedly associating a conditioned stimulus (CS; i.e., a cue) with an aversive unconditioned stimulus (UCS). This has been most readily demonstrated in animals but can also be demonstrated in human subjects as well (Marschner, Kalisch, Vervliet, Vansteenwegen, &

Büchel, 2008). These authors used positron emission tomography (PET) to identify brain areas associated with fear conditioning to a forearm shock that had been associated with a picture of a room. Two contexts (rooms) were each associated with a CS (a shape superimposed over the room) which served as either a reliable or unreliable predictor of an UCS (forearm shock). More activity in the hippocampus was found in response to the room and shape that indicated an unpredicted shock, showing the processing of fear encoding by contextual association in the hippocampus (Marschner et al., 2008).

Along with the hippocampus, the prefrontal cortex (PFC) and more specifically the right anterior PFC (APC) and right dorsolateral prefrontal cortex (DLPC), also reflect processing of contextual information in memory. Using fMRI, activity in the right APC and DLPC was similar across test conditions for tasks reflecting retrieval attempt, but varied across test conditions depending on the context of the test (Wagner, Desmond, Glover, & Gabrieli, 1998).

In their first experiment, Wagner et al. (1998) aimed to test the involvement of the right PFC against three hypotheses to determine its' role in retrieval. They used three types of test stimuli whereby words were either high accuracy (studied twice), low accuracy (studied once) or new (not studied) and tested participant's memory with an old-new recognition test. Out of three hypotheses – that the right PFC supports retrieval attempt (initiation of the search process or evaluation of search results (Kapur et al., 1995; Nyberg et al., 1995)), retrieval effort (Schacter, Alpert, Savage, Rauch, & Albert, 1996) or retrieval success (Rugg, Fletcher, Frith, Frackowiak, & Dolan, 1996) – results supported the retrieval attempt hypothesis, with equal activation across all types of stimuli. If activation was due to retrieval effort, activation of the right PFC was expected to be inversely related to retrieval success, with less effort and activation corresponding to successful retrieval. The retrieval-success hypothesis on the other hand, predicted that an increase in activation would be seen only with successful retrieval of the memory. Neither of these later two hypotheses fit the results however, as regardless of successful retrieval, activation was the same for each type of stimuli indicating that the APC and DLPC were implicated in retrieval attempt. This pattern of activation and fitting hypothesis differed in the second experiment however, when the researchers manipulated the test context.

Test context in this experiment was retrieval instructions which affected how participants initiated and carried out retrieval processes during the recognition test. Where they used the same instructions as that of the first experiment (to identify which items were old or seen before), they observed equal activation in the right APC and DPLC, consistent with the retrieval attempt hypothesis. However, when the context of the experiment was changed (biased instructions directing participants to look for a few old words among many new words or vice versa) more activation in the right PFC was observed instead. Therefore, Wagner et al. (1998) demonstrated that due to a change in context within the experiment, participants used different retrieval strategies which in turn reflected a difference in activation in the right PFC. The PFC along with the hippocampus, are therefore both critical structures in the processing of contextual information and the retrieval of episodic memories.

Neuroscience of the self and context

The hippocampus and PFC comprise part of a medial temporal-parietal *core network* thought to be involved not only in episodic and semantic memory of the past, but in processes such as in *self-projection* (Buckner & Carroll, 2007) or *mental time travel* (Tulving, 2002). These processes refer to ideas such as scene construction or projection of the self into a spatial context, and are common in imagination. Most commonly, imagination is studied in terms of imagining the future, however it can also refer to other forms of imagination such as re-imagining the past, or creating new imagined scenes in the present, and does not necessarily have a temporal contingency (for a review, see Schacter et al., 2012). For example, Hassabis, Kumaran, and Maguire (2007) conducted an fMRI study supporting the use of structures in the core network during the recall of previous episodic memories and the construction of imagined scenes and objects both previously imagined and newly constructed. Most notably, the hippocampus, posterior cingulate cortex, anterior medial PFC, and precuneus were engaged during the imagination (reconstruction and construction) of objects and scenes. Furthermore, patients with amnesia due to bilateral hippocampal damage were impaired in vividly imagining new experiences (Hassabis et al., 2007) possibly due to impairments with scene construction or imagining self-relevant future events. These results lend support to the fact that structures known to be involved in episodic memory also play a role in different types of imagination and complex scene construction.

Building on the idea of the core network as being implicated in imagination of spatially complex scenes, it has been proposed that these structures support the *scene construction theory* (SCT) (Hassabis & Maguire, 2007). Scene construction is the maintenance and elaboration of a mentally generated scene or event. By way of the hippocampus, scene construction acts a foundation for variety of functions such as episodic memory, spatial navigation, imagination and future thinking (Hassabis & Maguire, 2007). A similar hypothesis, the *constructive episodic simulation hypothesis* (Schacter & Addis, 2007), implies that the same core network supports both remembering the past and imagination of the future through the constructive nature of memory (Bartlett, 1932). By using episodic and semantic details from the past, the core network can recombine these details into future thoughts by imagination. One other hypothesis regarding the core network and its link to imagining the future concerns that of self-projection (Buckner & Carroll, 2007). Self-projection is one form of prospection, or thinking about the future, which may include imagining oneself carrying out tasks or making plans for future goals. Buckner and Carroll (2007) have also found support for this form of imagination and the connection among remembering the past and taking the perspective of others in the activation of the core network. Overall, there are several hypotheses regarding the basis for imagination, however, they all agree that the network that supports not only episodic memory but that of generative imagination is the same.

Seeing that there is a large component of the self in imagination, is not surprising that we often take this perspective when thinking about plans for future actions or remembering episodic details from our past. The medial PFC (mPFC), a lesser studied structure from the core network, seems to play a role in imagination and memory for self-relevant objects (Lin, Horner, Bisby, & Burgess, 2015). Noting the role of the mPFC in self-referential thoughts regarding subjective values of chosen objects, Lin et al. (2015) conducted an fMRI study demonstrating mPFC activation in response to imagined objects that were relevant to an imagined context. They created conditions whereby participants imagined a state of need (thirstiness, coldness, hunger, and tiredness) and a spatial scene and then viewed objects that were either congruent or incongruent with their imagined context. mPFC activation was seen to represent the value of an object, along with participants showing greater recognition memory for items congruent to their imagined context (items with greater value). This is relevant as it not only shows that the core network is again involved in scene construction and imagination, but that indices of memory can be influenced by the subjective value of an object. That is, objects that have more personal relevance and value (those congruent with the personal state of need) were better remembered.

In terms of an encoding strategy, mnemonics related to the self in imagination seem beneficial for recall. Grilli and Glisky (2010) demonstrated the *self-imagination effect* (SIE) in patients with neurological damage as well as healthy controls, whereby imagining an event from the perspective of the self lead to better memory as compared to semantic elaboration. They later compared the self-imagination strategy to three other mnemonic techniques (visual imagery, semantic elaboration and other-imagining), and found again that memory in individuals with neurological damage was significantly better when using the self-imagination technique (Grilli & Gilsky, 2011). Their results from a cued-recall test for spatial locations paired with objects even held after a 30 minute long delay, with self-imagination generating higher recall for the locations.

Overall, we can see that the process of memory, imagination and the self overlap and share an underlying neural network. Scene construction and the effect of context as well as self-projection and self-relevance come together in the generative power of imagination to influence memory. In the following experiments of this thesis, we attempted to capitalize on the power of self-relevant imagination and scene construction as ways to improve recall after a physical context change, which may be due to common processing by the underlying core network of the brain.

Implications of Imagined Contexts

As mentioned previously, mental reinstatement of an original environment was helpful for individuals trying to remember details about crimes they witnessed. Reinstating an environment that cannot be physically accessed in the moment may also have other benefits, especially in the areas of mental illness, aging or education. For example, more salient environments with specific physical features could be designed for aging individuals that may be easily mentally reinstated when needed. As well, any student would be glad to benefit from reinstatement of their study context during an examination without the physical (and impossible) effort of actually being there.

We have seen that self-imagined contexts seem to be an effective memory mnemonic in individuals with neurological damage and even healthy controls in improving recall (Grilli & Glisky, 2010; Grilli & Gilsky, 2011). The application of imagined contexts to other areas of memory research may also be helpful to individuals who are undergoing therapy for various psychological disorders. For example, individuals with anxiety disorders (most notably post-traumatic stress disorder (PTSD)), depression, and schizophrenia may demonstrate inflexibility in certain behaviours such as intrusive thoughts or memories that are separate from the current physical context (Maren et al., 2013). It has been suggested that PTSD may be an example of a psychological disorder whereby individuals either have inappropriate contextual processing or the reduced ability to use contextual cues, and has been studied by looking at extinction processes and activation of critical structures such as the hippocampus, amygdala and ventromedial PFC (vmPFC) (Milad et al., 2009; Rougemount-Bücking et al., 2011).

An extinction paradigm is a classical conditioning method where the association between a CS that has been associated with a US (aversive stimulus) is undone by repeatedly presenting the CS without the US, and is a technique used in exposure therapy to treat PTSD. Milad et al. (2009) and Rougemount-Bücking et al. (2011) used this paradigm along with contextual information to test the activation of different structures known to be impaired in PTSD. Firstly, a CS (light) was presented in one context (context A) along with the US (shock) until a fear response (CR, skin conductance response) was acquired. Then, in extinction training, the CS was presented in another context (context B) without the presentation of the US, thus making context B a *safe* context while context A was considered a *dangerous* context. Results revealed that participants with PTSD had impaired recall of the extinction memory and subsequent increases in fMRI activation in the dorsal anterior cingulate cortex (dACC) along with less activation in the hippocampus and vmPFC (Milad et al., 2009; Rougemount-Bücking et al., 2011). Normally, the vmPFC is known to exert inhibitory control over the amygdala (Rozenkranz & Grace, 2002) and should make use of context cues (i.e., the safe context B) in order to repress fear responses, however its decreased activation in patients with PTSD seems to suggest otherwise (Rougemount-Bücking et al., 2011). Therefore, based on the pattern of results with structures known to be involved in contextual processing, fear extinction deficits in individuals with PTSD may reflect difficulty with learning to use contextual cues in the inhibition of inappropriate fear responses.

Since imagined contexts have so far been demonstrated to be effective in protecting against context-dependent forgetting (Brinegar et al., 2013; Masicampo & Sahakyan, 2014), it is also useful to note their portable nature. Imagined contexts are portable in that they do not depend on the actual physical context and can thus be used anywhere. For example, there may be a case where extinction to a fear response is learned in one context, but it may not generalize to a context different from the extinction context. In terms of therapy, this may be difficult for the patient as they do not always remain in the *safe* context and the effects of context-dependent forgetting due to context change may cause the re-emergence of previously extinct behaviours, emotions, or memories. Thus, if an imagined context is used during therapy, regardless of the physical context the individual changes to, they may be able to mentally reinstate the *safe* imagined context. Figuring out how to overcome context-dependent forgetting is therefore an important phenomenon to investigate for its practical benefits.

The Absence of Context Effects

Seeing as context effects are not always reliable in both recognition and recall tests, it may be helpful to look more closely at conditions in which context effects failed to be elicited and why this was the case. For context effects to impact memory, the environmental information must first be incorporated into the memory trace and later be relevant to the user when probing memory for the desired information. Drawing on Glenberg's (1997) *environmental suppression theory*, Smith and Vela (2001) mentioned three hypotheses that could account for the absence of environmental context effects. The environmental suppression theory states that information about the immediate environment is automatically processed unless one makes efforts to suppress the contextual information (Glenberg, 1997). The environment can be supressed in three ways, through overshadowing, outshining, or mental reinstatement (Smith & Vela, 2001). Overshadowing and outshining supress contextual information at encoding and retrieval respectively, while mental reinstatement overcomes effects of the current environment by mentally reinstating a different environment. In these processes, context effects, that of worse memory in a different rather than same context, are negated, as the immediate influence of the environmental context is suppressed.

Some studies have attempted to manipulate various aspects of environmental contexts in ways that increase or decrease their salience but have still failed to find an effect of context where others have succeeded. Smith (2014) suggests that there may be other elements of a context such as stimuli and apparatus modality that researchers should be aware of when thinking about how individuals construct contexts. For example, Reed (1931) ran some reinstatement studies where she varied body posture and response modality as two types of contextual conditions. Participants were directed to learn material while in one body position (sitting or standing) and were either returned to the same or different posture during recall. In another experiment they were to encode the material in a written or oral way, and at test were asked to produce the information using the same or different modality. In both experiments, no effect of context was found. It was attributed to the fact that in both of these types of contexts, individuals are fairly adept at producing and remembering information without being so disturbed by them as they constantly change body positions and learning modalities throughout the day. Therefore, the context in this case may have been overshadowed or outshone because attention was not directed towards these automatic positions and modalities, making them irrelevant cues during test.

Fernandez and Glenberg (1985) also presented eight experiments that looked at various aspects of stimuli that did not affect recall when context was changed from study to test. They make a number of suggestions for why context information is not encoded or used at test, most notably repetition of stimuli presentation, stimuli difficulty, and self-generated retrieval techniques. For stimuli repetition, although increasing the number of presentations of stimuli resulted in overall better memory, when participants changed rooms from study to test, no context effect was found for recall. Even changing the experimenters present in the rooms or changing retention intervals did not make any difference in distinguishing the contexts. They also suggest that stimuli difficulty may detract from using environmental context cues during encoding as cognitive demands would be increased and less attention would be paid to contextual information. However, in their experiment using both difficult-to-remember and easy-to-remember word pairs, neither influenced recall after context change. Another hypothesis that seems quite likely is that participants do not use environmental contextual cues because they are using their own self-generated cues or techniques. For example, closing one's eyes or averting one's gaze during encoding may be a way to shut out environmental influences and improve memory (Glenberg, Schroeder, & Robertson, 1998).

To examine this, Fernandez and Glenberg (1985) designed an experiment where participants were either more or less likely to rely on environmental context instead of their own techniques, by having them learn pre-made sentences or generate their own sentences using the to-be-remembered words. The generation of their own sentences was expected to induce participants to use their own internal organizations to remember the words, while the learning of pre-made sentences was expected to rely on external contextual information. However, neither of these conditions influenced participant's ability to use contextual information as no context effect was found when participants changed to a different room for test. These results further highlight that features of stimuli should be further investigated as to their influence on contextual utilization.

In a similar study looking at dependency on environmental context, Wilhite (1991) tested participant's recall for a list of random words or a preconstructed paragraph. In this situation, he assumed that learning the random words would need to depend on the environmental context since no other cues were available, whereas memory for the paragraph would not depend on the environment as its organizational structure served as a more effective cue. Participants were directed to a room where they learned either the word list or paragraph and then remained in the same room or switched to a different room for recall. No effect of context was found in paragraph recall, as expected, however there was a significant effect of context on word list recall. Surprisingly, this effect was not in the usual direction. Participants recalled significantly more words in the different context than in the same context, which Wilhite (1991) refers to as the *negative environmental reinstatement effect*. This pattern of results although unusual, has occurred before, although results did not reach significance (Fernandez & Glenberg, 1985; McDaniel, Anderson, Einstein, & O'Halloran, 1989). Wilhite (1991) suggests that this is perhaps due to cue overload, where the same context word list group had to rely on overloaded cues during retrieval. During encoding, both different and same context groups would have overloaded cues while learning the words, however, during retrieval, the different context group would not have access to the overloaded cues and thus their performance was higher.

Lastly, a group of studies raises questions on the effect of context in education and classroom learning. If it was true that context change from study to test negatively affected memory, we would expect that over the years, students would perform poorly in school. This generally doesn't seem to be the case however. When students were tested in a different classroom than the one used for class lectures, they performed similarly to those who were tested in the lecture classroom (Farnsworth, 1985; Saufley, Otaka, & Bavaresco, 1985). Although the classroom seems like a more ecologically valid place to test context effects, there are many factors which can account for the absence of context effects. Questions on tests may require different learning or memory processes than those used in experiments; they may be more elaborative or associated with various study contexts outside of the lecture room. The fact that students typically study in different environments may decontextualize the study information, and in fact their memory may improve, such as with the multiple room manipulation (Smith, 1982; Smith, 1984). Context effects were also absent in studies with medical students who studied medical words, patient case studies, and random words and were tested in different locations such as the patient's bedside or the operating theatre (Koens, Cate, & Custers, 2003; Conveney, Switzer, Corrigan, & Redmond, 2013). Again, these authors note that participants may have used their own cues at test, decontextualizing the environment. Furthermore, the environments and some study words are familiar to these students which would have further reduced the influence of the environmental context. Although results like these are not encouraging for the finding of context effects, it makes sense that we are able to retain a lot of information even when switching through familiar and unfamiliar environments, varied body postures and modes of information input and output.

New Directions

Looking through the wealth of information discovered regarding the presence and absence of context effects, we can see that physical context effects for recall tests are overall quite robust. Examinations of the effect of imagined contexts on recall however is less well known and provides an interesting area to investigate. So far, imagined contexts seem to be a type of context which may act in a similar way to physical contexts, in that participants who reinstate the mental encoding context at test benefit in the same way that reinstatement of the physical context does to aid memory. This type of context potentially has many benefits not only in furthering our understanding of context effects, but also practically, as seen in cases of eyewitness studies. The use of mental reinstatement may also impact fields such as mental illness, aging and memory and even education. Understanding when context effects are present and absent may help to develop these fields.

The underlying neural network that connects memory, context, and imagination is also interesting as it supports not only these functions but that of self-related memory. The focus on the self in context-dependent memory is a new direction and has the potential to facilitate or even enhance memory in imagined contexts. Looking at studies that employed techniques which allowed participants to encode information in a self-referential manner and which saw benefits in memory performance, we proposed in this thesis to expand this concept to imagined contexts. Type of context plays a major role in influencing whether effects are present or absent, and self-relevant contexts may be a type that is also effective. Not only might self-relevant contexts be easier to construct due to their familiarity, but they may act as a stronger cue by this effect. Therefore, the novel position we took in this thesis was to bring the understanding of imagined contexts and self-related information in neuroscience together in order to examine the makings of an effective context.

Overview of Experiments

To further examine context effects, and particularly the impact of self-relevant imagined or mentally reinstated contexts, four experiments were conducted using recall for lists of random words. This study aimed to replicate previous results that found a clear effect of context when context was global, incidental, and extrinsic. We used rooms located in Wilfrid Laurier University as the environmental contexts, and a reinstatement paradigm similar to that used by Smith et al. (1978) and Smith (1979). Participants were presented with a list of words in one room and were tested for recall in either the same or different room. We expected to find an effect of physical context, in that participants who remained in the same context during test would recall more words than those that changed to a different room.

Another hypothesis we examined concerns the effectiveness of imagined contexts in reducing context-dependent forgetting when they were mentally reinstated at test. Building on studies conducted by Brinegar et al. (2013) and Masicampo and Sahakyan (2014), we developed contexts that were either based on a provided photo or generated by participants themselves. Participants were directed to imagine an environment while learning a set of words in one room and were then brought to another room where they were asked to mentally reinstate their imagined context during recall. A physical change in rooms was expected to cause context-dependent forgetting, however, with an imagined context held constant between both physical contexts, we predicted that participants would perform similarly to groups who did not change contexts. This manipulation is similar to the technique of preinstatement used by Brinegar et al., 2013.

Lastly, we wanted to test one aspect of imagined contexts, that being self-relevant imagined contexts. Determining what type of contexts are best reinstated or easily generated by participants may be beneficial to advancing our understanding of the way participants mentally represent environmental contexts, and what sort of features or associations are most prominent. Drawing inspiration from studies looking at the neuroscience of memory, context, and the self in the underlying core network, we proposed that self-relevant imagined contexts may be more meaningful to participants, and thus serve as effective environmental context cues. Participants created self-relevant contexts by imagining a place that was meaningful to them or somewhere that they visited often. For example, they may have imagined somewhere such as their bedroom or a vacation spot they particularly enjoyed. This condition was contrasted with the imagined context using a provided photo as reference instead.

Overall, four experiments were conducted to examine these hypotheses. The first one was designed to replicate basic physical context effects and mental reinstatement. Assuming that the first experiment would parallel findings already reported in the literature, the second experiment examined type of imagined context with the introduction of the self-relevant imagined context. Drawing from the non-significant results obtained from the first two experiments, we designed Experiment 3 as a revised version of Experiment 1. We adjusted some stimulus properties to better elicit context effects. Experiment 4 followed the non-significant results of Experiment 3, where we changed the type of experimental paradigm. Experiment 4 consisted of an interference paradigm, which is when participants learn one set of material in one context followed by another set of material in a different context and are tested on initial material in either the first (same) or second (different) context. The introduction of the interfering material in the form of a second word list along with a change in context were expected to increase participant's reliance on environmental cues from the first context. Results from this last experiment were also non-significant, adding to previous studies in the literature which found context effects unreliable.

Overall, participants were exposed to a physical context condition or an imagined context condition. They learned a set of words in one physical context (room) and either changed rooms or stayed in the initial room for a free recall test. Some participants were instructed either to imagine a context provided to them in a picture, imagine a self relevant context, imagine a previously introduced physical context, or not to imagine any context at all. Results obtained demonstrated that there was no effect of physical context, with groups that changed contexts performing the same as groups that stayed in the same context. This was regardless of whether groups were directed to imagine a context and reinstate it during test. Explorations for why this pattern of results was found in these experiments as well as in previous literature are considered in the general discussion.

Chapter 2: Experiment 1

Introduction

Experiments 1 and 2 were designed in tandem, with the expectation that Experiment 1 would confirm basic physical and imagined context effects on recall, while Experiment 2 expanded upon imagined contexts with the introduction of a self-relevant imagined context group.

In Experiment 1, basic physical context effects were expected to manifest as better recall in the same context group as compared to the different context group. Better recall was also expected in the group that reinstated the imagined context during retrieval. This experiment was designed to replicate the results of Brinegar et al. (2013) and Masicampo and Sahakyan (2014), where the reinstatement of an imagined context, even in a physically different context, would protect against context-dependent forgetting.

Three context condition study groups were created to examine the basic effect of context and imagined context on recall, group *same physical context* (SPC), group *different physical context* (DPC), and group *same imagined context* (SIC). Groups were created based on two general characteristics; context type and whether they changed contexts or not. Context types were physical context or imagined context, while the context change was either different or the same. The experimental design can be found in Table 1.

All groups began in one of the physical contexts (Lab, also referred to as context A) and listened to a set of words for which their recall would later be tested. If they were in the imagination context group, they were given additional instructions for an imagination task.

Groups then either changed physical contexts to the Office (context B) or remained where they were to complete the free recall task.

Method

Participants: A total of 48 students between the ages of 17 and 27 (M = 18.9, SD = 2.13; 40 females, 8 males) at Wilfrid Laurier University participated in this study, with 16 participants randomly allotted to each of the three groups (SPC, DPC, and SIC) and tested individually by the researcher. The number of participants in each group was kept at 16 for each following experiment in this study. Since participants were tested individually, 16 in each of the three groups was determined to be a manageable number for the researcher. Furthermore, in order to demonstrate an appropriate level of power in the experiments, the number of participants was similar to those used in studies with a similar design (Smith, 1979; Masicampo & Sahakyan, 2014).

Participants were recruited through the PREP (Psychology Research Experience Program) system and were compensated in the form of credits towards their eligible psychology course. This study was approved by the Wilfrid Laurier University Research Ethics Board and students signed a consent form (Appendix A) before beginning the study.

Apparatus and Materials: All procedures were carried out in either one or both of two rooms in the university. The room where all participants began the study, and where group SPC stayed for the entirety of the tasks, was context A, the Memory Laboratory in the Science Research Centre (Figure 1). The Lab consisted of a very small individual cubicle with an IBM compatible computer, a 17” colour monitor, keyboard, mouse, and JVC HA-X570 headphones. The cubicle had medium-grey coloured walls and was left dark with the lights turned off.

Participants had just enough space to sit in front of the monitor as the door to the cubicle was directly behind the chair.

The second room where some participants completed testing and recorded their responses, was context B, an Office in the Science Building (Figure 2). The Office is larger than the cubicle with two desks, including one which contained an identical computer, monitor, keyboard, mouse, and headphones as the Lab. The room was brightly lit by overhead lighting and some smaller string lights, and had bookcases filled with books and papers lining one of the walls. Several colourful, large-framed pictures and paper lanterns hung on adjacent walls. Lastly, a scented fragrance permeated the space which was also generally stuffy, due to poorer air circulation as compared to the Lab which was cooler in temperature. These distinctions worked to provide a noticeable sense of ambience which differed from the Lab.

The picture of a mountain pathway (Figure 3) which was shown to participants in the imagination condition (SIC) was drawn from a collection of natural images from Hancock, Baddeley, & Smith (1992) which consists of a variety of natural outdoor and indoor scenes. The original photo is in black and white and 256 x 256 pixels but was enlarged to 660 x 660 pixels for ease of viewing on the computer screen.

Stimuli in this experiment were two sets of 20 words; List 1 (L1, Appendix B) and List 2 (L2, Appendix B), and were randomly drawn from the Auditory Toronto Noun Pool compiled by Kahana (n.d.) (http://memory.psych.upenn.edu/Word_Pools). These words are taken from the Toronto Noun Pool, which in turn are a subset of the Toronto Word Pool (Friendly, Franklin, Hoffman, & Rubin, 1982). Stimuli were two-syllable words with average values of frequency and concreteness. Stimuli were presented and recorded using SuperLab 4.5 (Cedrus Corp.).

Filler tasks were simple math questions that were completed by typing the correct answer on the keyboard. Questions were in the format of addition, subtraction, multiplication and division of two simple numbers, for example the format $x + y = z$. Participants recorded their responses to the recall test on a piece of paper.

Procedure: All three groups were brought to the Lab cubicle and were left alone to complete the encoding portion of the experiment on the computer. It began with introducing a tone (an elevator *ding* sound) to participants, telling them the tone would signal the end of a task throughout the experiment. The tone was presented after a set of instructions or presentation of stimuli as well as any task requiring input by participants.

Group SIC was then asked to view the image of a mountain scene for 2 minutes while imagining themselves within the scene with their eyes closed. A tone signalled the end of the task where they could open their eyes. For groups SPC and DPC during this time, they were given simple math questions to answer instead of viewing the image. Then, for all three groups, an auditory word list (either L1 or L2) was presented through the headphones attached to the computer. Participants were asked to listen to and remember the words in the list. An additional imagination instruction was given to group SIC before the presentation of the word list. They were asked to imagine themselves within the scene they viewed and imagined previously as they listened to the words in the list. Following the word list presentation, groups exited the cubicle, with group SPC coming to sit just outside the cubicle with the researcher in the Lab and groups DPC and SIC following the researcher out of the Lab and to the Office.

Since the walk to the Office took approximately 2 minutes, group SPC was engaged in casual conversation with the researcher to match this time and prevent rehearsal of the word list. Groups DPC and SIC were also engaged in conversation with the researcher during the walk. After this delay, group SPC was sent back into the Lab cubicle while groups DPC and SIC took a seat in the Office to begin the recall task. Groups put on headphones attached to the computer where they received instructions about the recall task. They were then given a piece of paper and 3 minutes to write down any words that they could recall from before. Group SIC was given an additional instruction to re-imagine that they were in the previous imagined scene while performing the recall test. A tone signalled the end of this task and concluded the experiment. More detailed instructions for each study group can be found in Appendix A.

Design: A between-subjects design was used to examine the effect of the independent variable, context condition, at three levels (SPC, DPC and SIC) on the dependent variables, recall and intrusions. Another analysis looked at the effect of word list (L1 and L2) on the two dependent variables.

Results

Recall was measured as the number of words participants correctly remembered. Words were scored using two criteria, a strict or lax criteria. Words were deemed correct according to the strict criteria if they were exactly as those heard on the list they received. Correct words based on the lax criteria were counted if they were phonologically similar (e.g., *trader* instead of the correct word traito*r*, or *weather* instead of *feather*). Spelling did not matter in either of these criteria as long as the words were identifiable. Intrusions, the recollection of words not on the list, were also scored. Means for strict and lax recall as well as number of intrusions are reported in Table 2.

Word List. In order to asses if word list difficulty had an impact on recall, a one-way ANOVA was conducted for word list (L1 and L2) on recall. It was revealed that there was a significant impact of word list on strict recall $F(1, 46) = 12.02$, $p = .001$, $\eta^2 = .21$, and lax recall $F(1, 46) = 6.41$, $p = .015$, $\eta^2 = .12$. Participants who received L1 recalled more strict words (M = 8.73, SD = 4.10), than those that received L2 (M = 5.58, SD = 2.00). Participants hearing L1 also recalled more lax words (M = 9.18, SD = 4.15) than those that heard L2 (M = 6.85, SD = 2.05). There was no effect of word list on intrusions $F(1, 46) = 0.96$, $p = .33$, $\eta^2 = .020$.

Correct recall. As recall differed between the two lists, word list was included along with context condition in the analysis of recall. A 2 (L1 vs. L2) × 3 (SPC, DPC and SIC) ANOVA was conducted for number of words recalled (strict and lax criteria) and number of intrusions. A main effect was identified for word list and strict recall $F(1, 42) = 11.9$, $p = .001$, $\eta_p^2 = .22$ as well as lax recall $F(1, 42) = 6.15$, $p = .017$, $\eta_p^2 = .13$. The ANOVA revealed no interaction of word list × context condition for strict recall $F(2, 42) = 0.21$, $p = .81$, $\eta_p^2 = .010$, or lax recall $F(2, 42) = 0.19$, $p = .83$, $\eta_p^2 = .009$. Neither was there a main effect of context condition for strict recall $F(2, 42) = 0.57$, $p = .57$, $\eta_p^2 = .027$, or lax recall $F(2, 42) = 0.23$, $p = .80$, $\eta_p^2 = .011$.

Intrusions. There was no interaction of word list × context condition for number of intrusions $F(2,42) = 0.23$, $p = .80$, $\eta_p^2 = .011$. There was also no main effect of context condition for intrusions $F(2, 42) = 0.93$, $p = .40$, $\eta_p^2 = .042$, as well as no main effect of word list $F(1, 42) = 0.53$, $p = .47$, $\eta_p^2 = .013$.

Discussion

The aim of this experiment was to replicate the general context effect, whereby groups that complete a free recall task in the same environment where they first encode information perform better than groups that recall words in a different environment. Furthermore, the reinstatement of imagined contexts at recall was expected to result in better recall as well, as found in previous studies (Brinegar et al., 2013; Masicampo & Sahakyan, 2014). It was predicted that groups SPC and SIC would recall more words than group DPC, and that group SIC may even recall more words than group SPC. Masicampo and Sahakyan (2014) demonstrated that imagining a context different than the one physically present, because of the mental effort involved, was beneficial to memory regardless of the testing environment. Thus, it was possible that group SIC, who had to mentally generate their imagined context, may have remembered more words than group SPC who did not imagine anything at all.

The non-significant results of Experiment 1 demonstrate a failure to find an effect of context on recall. That is, there was no difference in number of words remembered whether groups stayed in or changed contexts from encoding to retrieval. Although recall was assessed using two scoring criteria, strict and lax recall, there was no difference between these two measures. These results are contrary to most studies examining the effect of context on recall, and support those that did not find any effect (e.g., Fernandez & Glenberg, 1985).

The non-significant effects of context and word list on intrusions is expected, indicating that the word lists are composed of reasonably distinct words and that participants were trying their best to only write those words in which they could absolutely recall correctly. Non-study words did not seem to impede participant’s abilities to recall actual study words during test.

The significance of word list on recall indicates something else about the strength of the word lists however. It could be that since participants who learned L2 recalled less words than those that learned L1, L2 might have contained more difficult-to-remember words. Also, word lists were assigned randomly by the computer, where L2 was assigned to 26 participants and L1 assigned to 22 participants, creating an unequal participant distribution among these two list groups. This issue was corrected in Experiment 2 where word lists were counterbalanced among the 3 groups.

Seeing as the overall effect of context was non-significant, there was also no difference between imagined (SIC) and non-imagined (SPC and DPC) context groups. The strength of imagined contexts to protect against forgetting in any context, even when changed from encoding to recall is therefore not as powerful as demonstrated in Masicampo and Sahakyan (2014). Something else to note is the attention paid to context during encoding. In other studies employing imagination or mental reinstatement, participants were directed to pay close attention to their imagined environment, in some cases pointing out actual items by taking their photo (Brinegar et al., 2013) or drawing a picture of the context (Smith, 1979) before imagination began. Efforts to get participants in the imagination condition SIC to notice their environment were included in this experiment; participants were asked to take note of any thoughts or sensory experiences they would feel were they actually in the mountain scene. However, this exercise may be seemingly less involved than drawing a picture or taking a photo of the context, thereby leading to less association of the words to the imagined scene. Experiment 2 included some aspects that were more involved in order to increase the salience of the imagined contexts.

Chapter 3: Experiment 2

Introduction

Seeing that Experiment 2 was run directly after and partly during Experiment 1, only a small change was made in light of the results of the previous experiment. The word lists were counterbalanced among participants so that an even number of participants received each list and the possible effect of word list difficulty would be reduced.

This experiment aimed to identify if self-relevant imagined contexts were more effective at protecting against context-dependent forgetting than the imagination of an uninteresting and impersonal mountain scene. It was assumed that a basic context effect would have been found in Experiment 1, and so the intention was to look more closely at imagined contexts.

Three new groups were created in this study, all who changed physical contexts and constructed or did not construct an imagined context during encoding and retrieval. Group *different physical context 2* (DPC2) was the same as group DPC from Experiment 1 and experienced no manipulation of imagined context. Two imagined context groups were included. Group *same imagined context 2* (SIC2) was the same as group SIC from Experiment 1. Group *self-relevant imagined context* (SRIC) experienced a different type of imagined context than SIC2.

A self-relevant imagined context was a personal and unique context that SRIC participants were asked to mentally generate. These were contexts that participants would find particularly vivid and easy to construct, that served an important meaning, or was somewhere they visited frequently. For example, they were asked to imagine a room in their house (e.g., their bedroom), somewhere they often visited (e.g., a school classroom), or a highly meaningful or stimulating environment (e.g., a vacation spot they enjoyed). As with group SIC2, the researcher directed participants to note any unique features or sensory experiences that would be noticeable in that environment, so that participants could imagine a vivid scene.

The experimental design is presented in Table 1. All groups began in the Lab where they listened to either L1 or L2 (as used in Experiment 1) and were either instructed to imagine a scene (as shown in Figure 3, or self-generated) or not during encoding. All groups then moved to the Office where they performed a free recall test with additional imagination reinstatement instructions being given to groups SIC2 and SRIC.

Method

Participants: An additional 54 participants were drawn from the PREP system and were given course credit for their participation. Six participants were not included in the analysis, four because the study was interrupted before recall could be completed, one due to a failure to follow instructions, and one because of prior knowledge of the experiment. Therefore, 48 total participants were evaluated with ages ranging from 17 to 29 (M = 18.9, SD = 2.32), including 39 females and 9 males. Sixteen participants were randomly assigned to each of the three study groups (DPC2, SIC2, and SRIC) and were tested individually.

Apparatus and Materials: The same rooms (Lab and Office) were again used as the two distinct context locations. Two additional materials were added in the form of two, 1-item, 5-point scales. The first scale that was presented to groups SIC2 and SRIC asked the question, “How vivid/clear is your imagined environment at this time?” with possible answers being, “1 – not vivid at all (unclear), 2 – vaguely vivid, 3 – neither clear nor unclear, 4 – mostly vivid, and 5 – very vivid (clear)”. The second scale was presented to group DPC2 and asked the question, “How tired do you feel right now?" with possible answers being, "1 – exhausted, 2 – tired, 3 – neither tired nor energized (neutral), 4 – alert, and 5 – alert (energized)". Participants again recorded all responses on the computer and a piece of paper.

Procedure: Detailed study instructions are presented in Appendix A. All three groups were brought into the Lab cubicle where they began the encoding phase and were familiarized with the tone that signalled the end of tasks. Groups SIC2 and SRIC were given a 1 minute imagination task where they were either shown the mountain scene (Figure 3) or asked to construct a self-relevant imagined scene in their mind (group SRIC). Participants were instructed to close their eyes and imagine that they were within the imagined scene as well as take note of any relevant details or sensations that they would experience were they actually in that environment. A tone signalled when they could open their eyes. They were then given 3 minutes to write down a short descriptive paragraph about the scene they imagined. Following the paragraph task, they were again given 1 minute to fully visualize their scene. During this 5 minute imagination task, group DPC completed simple math questions instead of imagining a scene.

L1 or L2 was then presented to each participant through the headphones and they were asked to listen and remember the words. Groups SIC2 and SRIC were given additional instructions to imagine themselves within their previously imagined scene as they listened to the word list. The 5-point scales were presented to participants three times throughout the word list; at the beginning, after a presentation of 10 words, and at the end of the list. Groups SIC2 and SRIC indicated the level of vividness of their imagined scene at the time on a scale of 1 (unclear) to 5 (clear), while group DPC2 indicated their level of fatigue from 1 (exhausted) to 5 (alert). Groups indicated their responses by pressing the corresponding number key on the keyboard. The scale presented to group DPC2 was meant as a filler task to match the time and disruption of groups SIC2 and SRIC spent filling in their questionnaires. Following the word list presentation, all groups exited the Lab and moved to the Office, engaging in casual conversation with the researcher along the way.

In the Office, each group was given 3 minutes to write down any words they could remember from their word list. Groups SIC2 and SRIC were asked to re-imagined themselves in their previous imagined context during the task. Following the recall task, these two groups were given 3 minutes and asked to write another short descriptive paragraph detailing the scene as it appeared in their mind during recall. Group DPC2 again completed math questions instead of the paragraph task. A tone signalled the end of the paragraph and math exercises, and the completion of the experiment.

Design: A between-subjects design was used to examine the effect of context at three levels (DPC2, SIC2, and SRIC) on the dependent variables, recall (based on the strict and lax criterion) and intrusions. A second analysis compared the effect of word list on the dependent variables. Another analysis examined the effect of imagined context conditions (SIC2 and SRIC) on average values of vividness ratings.

Results

Word List. A one-way ANOVA performed on word list and recall indicated no effect of word list (L1 or L2) on strict recall $F(1, 46) = 0.26$, $p = .62$, $\eta^2 = .006$, nor lax recall $F(1, 46) = 0.40$, $p = .53$, $\eta^2 = .009$. Groups recalled an average of 6.85 ($SD = 3.11$) and 7.58 ($SD = 3.18$) words for strict and lax criteria respectively. There was also no effect of word list on intrusions $F(1, 46) = 0.84$, $p = .36$, $\eta^2 = .018$.

Correct recall. Mean number of words recalled and number of intrusions are presented in Table 3. A one-way ANOVA conducted on the effect of context condition on strict recall revealed no effect of context $F(2, 45) = 0.37$, $p = .70$, $\eta^2 = .016$. There was also a non-significant effect of context on lax recall $F(2,45) = 0.52$, $p = .60$, $\eta^2 = .023$. There was a non-significant effect of context condition on number of intrusions $F(2, 45) = 0.16$, $p = .85$, $\eta^2 = .007$. Although non-significant, group means for strict and lax recall were in the direction favouring same context effects with imagination groups SIC2 and SRIC recalling more words than the different context group DPC2. Also, group SIC2 recalled the most words of any group.

Vividness ratings. Means of the vividness ratings for imagination groups SIC2 and SRIC are presented in Table 4. Averages of all three measures for each group are also presented. A one-way ANOVA was conducted on context conditions SIC2 and SRIC and average vividness ratings. There was no significant difference in vividness ratings across context conditions $F(1, 30) = 1.02$, $p = .32$, $\eta^2 = .033$.

Discussion

No significant effect of word list on recall was detected in this experiment, indicating that participants recalled words from each list to a similar extent. Notably, the mean number of intrusions were also low for all groups (Table 3) and so words in the lists may be equally distinguishable and memorable to participants.

Again, no effect of context nor a reliable effect of mental reinstatement was found. However, means were in a direction that would be expected were there a context effect, with better recall in the same context reinstatement groups (SIC2 and SRIC) compared to the different context group (DPC2). Also, similar to the results found by Masicampo and Sahakyan (2014) where groups that imagined a previously visited context at test recalled more than the transformed context A group (A’), group SIC2 recalled more than group SRIC. Group SRIC is similar in some ways to group A’, in that both had to generate a context that was not present using their own imagination. Group SIC2 on the other hand is similar to the other imagination groups in their study. Where these other groups imagined a previously visited environment, group SIC2 viewed a photo which is similar to viewing a previously visited room. Although it was anticipated that self-relevant contexts may invoke better recall than impersonal contexts when reinstated, means favour the opposite direction, such as those discovered by Masicampo and Sahakyan (2014).

Some reasons for why context effects were absent in this and the first experiment were examined, and an improved version of Experiment 1 was designed for Experiment 3. It was determined that in order to create context effects, we needed to increase the reliance of groups on environmental cues. Since it is assumed that environmental cues are utilized when other more salient cues are unavailable, we focused on making the environment more necessary for recall. Self-relevant contexts were also not examined further.

It may be that imagination groups did not find their imagined context salient enough and so did not benefit from imagined environmental cues. In some other studies where effects were found for mental reinstatement, more effort was placed into getting participants to vividly encode their imagined scene through reminders during the experiment (Smith, 1979; Brinegar et al., 2013). In this experiment, although we provided participants with many opportunities to imagine their scene by way of the paragraph and vividness rating tasks, participants may not have been attending to any specific details of their environments. Generally, the elements that make up a context or environment are noted as important cues that must be mentally reinstated during re-imagination at recall in order to aid memory performance (Brinegar et al., 2013; Masicampo & Sahakyan, 2014). Thus, a task in Experiment 3 was introduced that asked participants to write down actual details of their environment before performing the recall test. This is similar to the method used by Smith (1979) where participants drew a picture of the future encoding room to note specific details. Furthermore, pictures of the imagined context were presented at the beginning and end of the word list to visually remind participants of the actual scene.

One main issue with the presentation of the mountain scene to SIC and SIC2 participants in Experiments 1 and 2 could be that they found the image dull and difficult to imagine. The photo presented was in black and white, and although enlarged, was still small and somewhat grainy when viewed on the computer. The descriptive paragraph task was used to asses if participants were noting details of the scene and that they were holding a consistent image in their mind during encoding and test. Generally, participant's paragraphs had a consistent description noting details of the mountains, the dark atmosphere and a river or path between the mountains. In terms of vividness ratings, although non-significant, the ANOVA on imagined context condition and average vividness ratings showed that group SRIC rated their context slightly more clearly throughout the word list presentation than group SIC2. This is interesting as the means for recall demonstrate that group SIC2 recalled slightly more words than group SRIC. One would think that the more vivid a scene is, the easier it would be to reinstate and use in recall. However, with the non-significant results it is difficult to understand the relationship between vividness of a scene and effectiveness of imagined cues.

Looking at Table 4, means for each scale value were mostly consistent over time, but tended to be somewhat higher in the beginning and drop towards the end. This was expected as it is difficult to keep a scene so vividly in mind while listening to words at the same time. Although the paragraph and vividness rating tasks showed mostly constant results, participants may still have had difficulty immersing themselves in their scene due to lack of details. A new photo which was colourful and large (Figure 4) was thus presented to participants in Experiment 3 in order to overcome a possible lack of salience. In changing these few items to bring imagination participant’s attention to their environment and to increase the reliance on environmental cues, it was expected that context effects would be more likely due to the contrast between physical and imagined contexts.

Chapter 4: Experiments 3 and 3b

Experiment 3

Introduction

Experiment 3 was a replication of Experiment 1 with some features changed to make imagined environments more salient and to increase overall recall. Seeing that recall levels were quite low and variance sometimes large in the previous two experiments, the word list was presented twice to increase the overall number of words recalled in all groups. Other efforts to improve salience of the imagined environment were implemented through a new picture presented to the imagination group, repeated presentation of the picture throughout encoding, and a task requiring the imagination group to note specific details of the environment prior to recall.

Another change was made to study and test procedures. In order to maximize the difference in physical environments, presentation of stimuli and participant responses in the Lab were restricted to the computer while instructions and recall output in the office were oral and written, respectively. This was in contrast to the previous two experiments where regardless of the context change, all participant instructions and responses were presented on the computer. Lastly, an amalgamation of L1 and L2 into L3 was done to create a balanced word list that participants could more easily remember.

Three groups were included which were the same as those in Experiment 1. Group *same physical context 3* (SPC3), group *different physical context 3* (DPC3), and group *same imagined context 3* (SIC3). All groups followed the same procedure as that in Experiment 1 (see Table 1), with some changes noted below.

Method

Participants: Forty-eight participants (37 female, 11 males) ranging from ages 17 to 22 (*M* = 18.7, *SD* = 1.03) were recruited from the PREP system and given course credit for their participation. Participants were randomly assigned to one of the three context condition groups (SPC3, DPC3, and SIC3) and tested individually. This study was approved by the Wilfrid Laurier University Research Ethics Board and participants signed a consent form (Appendix A) prior to participation.

Apparatus and Materials: The word list for this experiment, list 3 (L3, Appendix B), was randomly drawn from the 40 words in L1 and L2 which were used in the first two experiments. L3 contained 25 words. The word *shower* was omitted from the selection as participants often confused this word for the similar sounding word *sour*. The previous picture of a mountain scene that was used for the imagined context was replaced with a picture of a colourful beach scene (Figure 4). The picture shows a tropical beach with blue water, floating boats, sand, several green palm trees, multiple beach chairs, and thatched umbrellas. The same two physical contexts from the first two experiments were used again, with the only modification being that in the office, the desk containing the computer was covered with a shower curtain. The curtain was blue with a design of dispersed green, tropical flowers. The computer was covered as to not represent any physical elements from the Lab, and maximize their difference as distinct contexts. Stimuli were presented and recorded using the SuperLab 5 program (Cedrus Corp.) and a piece of paper.

Procedure: As in the previous two experiments, groups began in the Lab where they received information about the study and were familiarized with the tone that signalled the end of a task on the computer (see Appendix A). Group SIC3 viewed the beach scene and imagined themselves within the scene for 2 minutes while groups SPC3 and DPC3 completed simple math questions. Groups were then presented with L3 and asked to listen and remember these words. Word order presentation was random for each participant with 2 seconds of silence between each word. Group SIC3 was asked to imagine themselves in the beach scene while they listened to the words. After the word list presentation, the beach scene was briefly presented again to group SIC3 for 5 seconds while groups SPC3 and DPC3 viewed a black screen instead. The word list was then presented a second time, thus ending the first part of the experiment.

After this encoding period, participants moved onto the recall test. Groups DPC3 and SIC3 moved to the Office while group SPC3 stayed in the Lab and all participants engaged in casual conversation with the researcher during this time. Before the recall test, group SIC3 was given 2 minutes to write a short list of any details about the beach scene that they could visualize. Groups SPC3 and DPC3 again did math questions for these 2 minutes. All groups were then asked to write down (DPC3 and SIC3) or type (SPC3) any words they could remember from before, with additional instructions given to group SIC3 to re-imagine themselves in the beach scene. The recall task took 3 minutes. All instructions given in the office were oral, with responses to math questions and recall written on paper while the instructions and recall responses in the Lab were delivered by computer.

Design: A between-subjects design was used was used to evaluate the effect of context at three levels (SPC3, DPC3, and SIC3) on number of words recalled (strict and lax scoring criteria) as well as number of intrusions. Another analysis looked at the effect of context and level of recall (high vs. low) on strict and lax recall.

Results

Correct recall. Table 5 presents the mean number of words recalled in each context condition as well as the number of intrusions. Average number of words recalled for each group although non-significant, seemed to follow a trend that would be expected if a context effect was present. Same context groups SPC3 and SIC3 recalled more words than the different context group DPC3, with the imagination group SIC3 recalling the most words under both strict and lax scoring criteria. A one-way ANOVA revealed no effect of context on strict recall $F(2, 45) = 1.05$, $p = .36$, $\eta^2 = .044$ or lax recall $F(2, 45) = 1.19$, $p = .31$, $\eta^2 = .050$. There was also a non-significant effect of context on intrusions $F(2, 45) = 1.57$, $p = .22$, $\eta^2 = .065$.

Median split analysis. Seeing that the range in number of words recalled was quite large, with a minimum value of 1 word and maximum value of 20 words, a median split analysis based on recall scores was performed. A 2 (above median vs. below median) × 3 (SPC3, DPC3, and SIC3) ANOVA was performed in order to look at the effect of level of recall (high, above median vs. low, below median) and context condition for both strict and lax scoring.

Mean number of strict words recalled for each context condition above and below the median are included in Table 6. The ANOVA for strict recall revealed a main effect of level of recall $F(1, 42) = 70.5$, $p < .001$, $\eta_p^2 = .63$. There was a marginal main effect of context condition $F(2, 42) = 2.63$, $p = .084$, $\eta_p^2 = .11$ with group SIC3 recalling the most words, followed by group SPC3 and group DPC3 recalling the least. There was no interaction of context condition × level of recall $F(2, 42) = 0.38$, $p = .69$, $\eta_p^2 = .018$. An ANOVA for level of recall and context condition was also performed for lax recall, but results are not reported here due to a negligible difference between the two scoring criteria.

Discussion

Efforts to make the imagined environments more salient in this experiment seem to have been beneficial for participants. Overall recall was higher than in Experiments 1 and 2, most probably due to the repeated presentation of the word list. The non-significant effect of context on recall as well as the main effect of context when looking at high levels and low levels of recall demonstrate that same context groups recalled more words than the difference context group. Furthermore, when comparing the same context groups, the imagination group SIC3 recalled more words than the non-imagination group SPC3. These means are in the direction that is predicted when context effects are apparent. Efforts to make the imagined context more noticeable and useful as a cue using repeated picture presentations and the picture description task may have helped participants in group SIC3. Although non-significant, the finding that the imagination group performed better than not only the different context group (DPC3) but the same context non-imagination group (SPC3), comes closer to results of previous imagination studies by Brinegar et al. (2013) and Masicampo & Sahakyan (2014).

In order to maximize the difference between same and different context groups even further, another different context group was created in Experiment 3b. Seeing that the imagined context appeared to be salient enough to participants, the non-significant context effects may be due to the physical contexts instead. It is possible that the two rooms used as the different physical contexts were not distinct enough to participants and when they switched rooms, there was not enough of a change for context effects to occur. Many of the basic details and associated cues from the first room may be similar to the second room (e.g., desk and chair, feeling of being in an experimental room).

Although efforts were made to make these two rooms quite different, using room decoration, scents and even different response modalities (computer vs. hand written), participants may view the two rooms as simply two ordinary indoor school rooms. In the studies by Brinegar et al. (2013) and Masicampo and Sahakyan (2014), one of their physical environments included an outdoor location. An indoor and outdoor contrast would definitely create two distinct environments; however we were unable to create this distinction in our following experiment due to weather conditions. Instead, another indoor room that was very different in scale from the two previous indoor rooms and which shared some outdoor elements was determined to be adequate.

Experiment 3b

Introduction

Although non-significant, the trend in the means towards what would be expected from an effect of context was investigated further in this experiment. It was decided to see if the contrast between same and different contexts in Experiment 3 (SPC3 and DPC3) could be increased by testing a new different physical context group DPC3b, and comparing it to the previous results of group SPC3. In order to create a greater contrast between contexts, the different context was changed from the office to the Science Atrium in the Wilfrid Laurier Science Building. Increasing the difference between two similar rooms to one room and a large, open space was done to maximize the dissimilarity between encoding and recall contexts, and to find an effect of context.

Method

Participants: An additional 16 participants drawn from the PREP pool were recruited and given course credit for their participation. All participants were assigned to the different context group DPC3b. Ages ranged from 17 to 22 (M = 19, SD = 1.46) with 10 females and 6 males.

Apparatus and Materials: Materials used for the encoding process were the same as in Experiment 3, with the only change being the room used for the different context condition. Previously the Office was used as the different context where groups SIC3 and DPC3 performed the recall test. This context was changed to the Science Atrium (context C) in the Wilfrid Laurier Science Building (Figure 5). The Atrium is a large open space containing a central area filled with desks for student study, a Tim Hortons coffee shop at the west end, and a large staircase and elevator leading to the upper areas of the building at the east end. The tall ceiling of the Atrium is lined with sky lights and among the desks are living trees which provide a natural and pleasant feel for students in the seating area. Often there are events from different student clubs happening at some desks as well as frequent student travel through the central area, making the Atrium a frequently busy conversational and study area. The desk and two chairs used for this experiment were near the centre of the seating area under the shade of a tree. The researcher and participant sat across from one another.

Procedure: The encoding process proceeded the same way as for group DPC3 from Experiment 3, with DPC3b participants being brought to the Lab and listening to L3 from the computer. After this, participants were brought downstairs to the Atrium and to the desk used for the recall test. They were given 2 minutes to complete as many math questions as they could on a piece of paper and then were given 3 minutes to write down any words they could remember from the study list.

Design: A between-groups analysis was used to evaluate an effect of context at two levels (SPC3 and DPC3b) on the dependent variable recall including strict and lax recall, as well as intrusions.

Results

Strict recall means were again in the direction that would be expected by a context effect with SPC3 recalling more words (M = 8.06, SD = 3.28) than group DPC3b (M = 7.50, SD = 2.81) as well as with lax criteria (SPC3: M = 8.19, SD = 3.33, and DPC3b: M = 7.56, SD = 2.83). Mean number of intrusions for SPC3 (M = 0.63, SD = 0.89) and DPC3b (M = 0.31, SD = 0.60) were similar. A one-way ANOVA used to examine the effect of context revealed a non-significant effect on strict recall $F(1, 30) = 0.27$, $p = .61$, $\eta^2 = .009$, as well as lax recall $F(1, 30) = 0.33$, p

= .57, η^2 = .011. There was also a non-significant effect on intrusions $F(1, 30) = 1.36$, $p = .25$, η^2 = .043.

Discussion

Changing the physical different context to a seemingly more distinct context in this experiment as compared to the Office from Experiment 3, did not make a difference when comparing same to different context conditions. We attempted to make the Atrium a similar context to the outdoor contexts used by Brinegar et al. (2013) and Masicampo and Sahakyan (2014), as the outdoor contexts contrasted well with their indoor contexts. The Atrium is as similar as possible, however due to weather restrictions that would not be comfortable for participants, they could not actually be outside. From this change in different contexts, group DPC3b recalled only an average of 0.37 more words than group DPC3, making the change from Office to Atrium negligible.

Therefore, the different physical contexts used in the previous three experiments must be comparable in terms of distinctness and need not be considered further. Looking back to what makes contextual information necessary, the environment or context where item encoding takes place has to be emphasized in order to reduce de-contextualization. The environment is considered an effective cue when other or better retrieval cues are not available, thus requiring it to be included in the memory trace (Smith & Vela, 2001).

In terms of reducing decontextualization, one factor which is difficult to change and to predict is the extent to which participants use their own self-generated mnemonic techniques. In fact, some participants were observed or mentioned using such techniques as saying and repeating words out loud, reinstating the body posture used during learning, and making visual stories out of the words. In Experiments 1 and 2, participants commonly mentioned associating the words with aspects of the picture of the mountain scene or the beach. Also, since closing the eyes during encoding have been shown to improve memory (Glenberg et al., 1998), although instructions were explicitly given to imagination group participants to do so, same and different physical context groups may have done this as well. Closing the eyes during encoding may have allowed participants to decontextualize their environments because they would not be attending to visual details of the physical context. These self-generated techniques are difficult to control for as participants engage in them spontaneously and without the knowledge of the researcher. Therefore, in the following experiment we attempted to make it necessary for participants to rely on context cues, not by controlling for self-generated techniques but by explicitly telling participants to use context cues. In this way, by having them focus on the context during encoding and at test, they may find these cues the most helpful for recall.

Chapter 5: Experiment 4

Introduction

To maximize the chance that the environment or physical context where encoding takes place was incorporated into a memory trace, all participants were directed to focus on the environment both during study and test. Since many other factors may contribute to decontextualization, utilization of the encoding context as a memory aid was explicitly mentioned to all participants. Furthermore, two word lists were used (with participants being asked to recall the first one) to reinforce the likelihood that participants needed to rely on their memory for the source of the first list. In order to do this successfully, they needed to use physical context cues from the original encoding environment to remember the words. Experiment 4 aimed to find a basic physical context effect on recall as well as look at the effect of interference when there are multiple sources of information (word lists).

An interference paradigm was used to carry out these manipulations. Participants learned the first word list in the Office (context B) and the second list in the Lab (context A) or again in the Office. They then returned to the Office (same context condition) or remained in the Lab (different context condition) to recall the first list.

The introduction of the interference paradigm attempted to highlight the reliance on environmental cues. Participants may have thought they needed to be able to recall both lists, and would more likely distinguish lists based on environmental contexts seeing as there were no other relevant cues available. However, those participants that learned the second, interfering list in the same context as the first list would find environmental cues less useful as compared to those who learned the second list in another context. Context B would become associated with two lists, therefore contributing to cue overload.

Four context conditions were created, with each group being either in the same or different context for recall as encoding. The *same condition interference* (SCI) group studied L3 and L4 in context B and completed recall in B as well. The *different condition interference* (DCI) group studied L3 and L4 in B and completed recall in context A. The *different context* (DC) group studied L3 in B, L4 in A and completed recall in A. Finally, the *same context* (SC) group studied L3 in B, L4 in A, and completed recall in B. Essentially, all groups studied L3 in context B, either studied L4 in the same (interference) or different context, and then completed recall in the same or different context as L3. The experimental design is presented in Table 7.

It was predicted that groups SCI and DCI who learned the second, interfering list along with the first list in context B would recall the least amount of words, with group SCI performing worse than group DCI due to being in the same context for both list learning and recall. Context effects were expected in groups DC and SC. Context effects would manifest as better recall in group SC due to being reinstated in the same context as L3 learning, and worse recall in group DC who would not benefit from reinstatement. Although both of these groups are expected to perform better than groups SCI and DCI due to being better able to distinguish the two lists, if context is important for recall, then group SC should recall more words than group DC. Overall performance from worse to best is predicted as group SCI followed by DCI, DC, and finally SC.

Methods

Participants: Sixty-five participants were recruited from PREP and given course credit for this experiment, with 16 randomly assigned to each of the four context groups (SCI, DCI, DC, and SC) and tested individually. One participant was not included in the analysis as the experiment was interrupted before recall data could be collected, and was dropped to ensure an equal number of participants per group. Ages of participants ranged from 18 to 28 (M = 19, SD = 1.92) with 55 females, 7 males, and 2 non-identified or other gender individuals. This study was approved by the Wilfrid Laurier University Research Ethics Board and participants signed a consent form (Appendix A) before beginning the experiment.

Apparatus and Materials: Two word lists were used, each consisting of 25 words. L3 from Experiment 3 and 3b was used as the first word list and list 4 (L4, Appendix B) was created by drawing 25 new words from the Auditory Toronto Noun Pool. The two rooms used for the different contexts were again the Lab (A) and the Office (B). Distraction tasks were a sheet of 80 simple math questions and a moderately-difficult connect-the-dots picture.

Procedure: Participants began in the Office instead of the Lab this time, where they were given instructions about the experiment. These instructions can be viewed in Appendix A. They were told that the researchers were interested in looking at not only memory for words but memory for where the words were learned as well. They were given an example to help them understand this concept. It was made clear that they should try to associate the words that they were about to hear with the Office. Participants were also told that they would receive two word lists but to keep the words lists separate from each other. All groups received the same instructions except for group SCI who was not given information about having to associate the words with the Office as they would be in the same environment for both learning and test.

The first word list (L3) was then presented to all participants, with words being played in a random order through the headphones by the computer. Groups DC and SC then proceeded to walk to the Lab while engaging in conversation with the researcher. Meanwhile, groups SCI and DCI completed the simple math questions in the Office. All groups then heard the second list (L4) in which words were also presented in a random order. Before this list was presented, groups DCI, DC, and SC were reminded to not only remember the words but to keep the place where they learned these words in mind as well.

Groups then moved or stayed in their room for the recall task. Group DCI moved to Lab while group SC moved to the Office and the other two groups SCI and DC stayed where they were (Office and Lab, respectively). During the 2 minutes that groups DCI and SC were moving to the other rooms, groups SCI and DC performed a connect-the-dots exercise. Further instructions to remember the context where L3 was heard during recall was given to groups DCI, DC, and SC before the recall task began. All groups were then given 3 minutes to write down any words they could remember from the first list (L3) onto a piece of paper.

Design: A between-subjects design was used to look at the difference in the dependent variable (number of words recalled, strict and lax scoring criterion) as well as number of intrusions between the four context groups (SCI, DCI, DC, and SC).

Results

Mean number of words recalled and number of intrusions are presented in Table 8. Mean number of words recalled for all groups was fairly similar, with the average strict recall for all groups being 4.48 words (SD = 2.73) and lax recall being 4.64 words (SD = 2.82). A one-way ANOVA examining context on strict recall revealed no effect $F(3, 60) = 0.16$, $p = .92$, $\eta^2 = .008$.

There was also a non-significant effect of context on lax recall $F(3, 60) = 0.31$, $p = .82$, $\eta^2 = .015$ as well as a marginal effect on intrusions $F(3, 60) = 2.27$, $p = .09$, $\eta^2 = .10$. Groups DC and SC experienced slightly more intrusions of non-list words than groups SCI and DCI.

Discussion

Context effects in this experiment seem to be almost eliminated, seeing as all groups performed equally as well on the recall test. Although there was a slight trend for same context groups SC and SCI to perform better than different context groups DC and DCI, this difference was non-significant, demonstrating no effect of context on recall.

The effect of context on intrusions was marginally significant with the trend in the means being opposite than predicted. We predicted that due to the second list being presented to groups SCI and DCI in the same context that they would suffer more from cue overload and thus experience more intrusions. However, the opposite was found, where groups SC and DC experienced more intrusions. Most intrusions that were made among groups did belong to the second list, indicating that the list did in fact interfere with their recall of the first list.

Groups DC and SC may have suffered from physical disruption which caused them to confuse the initial source of each word list. Physical disruption may have resulted from the fact that groups DC and SC changed back and forth between rooms during list learning, whereas groups SCI and DCI remained in the same environment. Thus, source misattribution and unfamiliarity of the learning rooms may have contributed to the higher number of intrusions in the former groups, leading not only to lowered overall recall, but difficulty distinguishing word lists. Previous studies have employed methods to make disruption equal among all study groups, such as having participants draw a picture of the other visited context to familiarize themselves with the room whether or not they were to return there for the recall test (Smith et al., 1978; Smith, 1979; Wilhite, 1991). Although distraction tasks were given to other groups (i.e., math questions, connect-the-dots), these results may indicate that they were not sufficient in disrupting participants to the same degree.

The interference paradigm used in this experiment seems less able to predict context effects than the traditional reinstatement paradigm used in the first three experiments. Perhaps this is why the reinstatement paradigm has been used more commonly in current research instead (Hockley & Bancroft, 2015). Participants may automatically distinguish the lists based on other criteria than the environment, thus making a change in contexts for list learning (which would usually lead to worse memory) unimportant.

Chapter 6: Cumulative Analysis of All Experiments

With the overwhelmingly non-significant results in the four experiments carried out in this study, we turned to an examination of power of the previous experiments to detect context effects. Trends in the means of recall in Experiments 2 and 3 pointed in the direction of context effects, with same context groups recalling slightly more words than different context groups. However, factors such as the small sample size of each group and variance (i.e., range of words recalled, large standard deviations) could have contributed to reduced power in detecting an effect of context. Sample sizes in the four experiments conducted here were relatively small, with 16 participants per context condition group for a total of 224 participants. These sizes are similar to previous studies demonstrating context reinstatement using imagined contexts by Smith et al. (1978), Smith (1979), and Masicampo and Sahakyan (2014), but differ from the large group sizes used by Brinegar et al. (2013). Efforts were also made to make the four experiments of the current study similar to the methodology in previous studies where context effects were found. Lastly, context effects may be associated with small effect sizes, making them difficult to detect. Smith and Vela (2001), in their meta-analysis of environmental context effects, discovered that context-dependent memory experiments typically have a small Cohen's (1988) effect size of $d = .28$. Cohen (1988) suggested that effect sizes of around $d = .20$ are considered small with $d = .50$ being medium and $d = .80$ being large.

To address the questions of power and effect size, we compared the same and different physical context groups across all four experiments in one analysis. A 2 (same vs. different) × 4 (Experiment 1, 2, 3, and 4) ANOVA was conducted on both strict and lax recall scoring criterion. By combining smaller groups into two context condition groups, we expected to increase the power of detecting context effects that would match the observed trends in Experiments 2 and 3.

The number of strict words recalled in each context condition by experiment number are presented in Figure 6. The ANOVA revealed a main effect of experiment number $F(3, 216) = 13.2$, $p < .001$, $\eta_p^2 = .16$ but no main effect of context $F(1, 216) = 1.84$, $p = .17$, $\eta_p^2 = .008$. Post-hoc analyses using the Bonferroni Correction indicated that the only significant difference was between Experiment 4 (*M* = 4.48, *SEM* = 0.40) and the other three experiments, Experiment 1 (*M* = 7.00, *SEM* = 0.49), Experiment 2 (*M* = 6.75, *SEM* = 0.47), and Experiment 3 (*M* = 7.91, *SEM* = 0.40). No interaction of context × experiment was revealed $F(3, 216) = 0.27$, $p = .85$, $\eta_p^2 = .004$.

Mean number of words recalled under the lax scoring criterion in each experiment according to the context condition are shown in Figure 7. The same 2 (context condition) × 3 (experiment number) ANOVA was conducted on the number of lax words recalled. A significant main effect of experiment number was found $F(3, 216) = 15.2$, $p < .001$, $\eta_p^2 = .17$. There was also no main effect of context $F(1, 216) = 2.28$, $p = .13$, $\eta_p^2 = .010$. Post hoc analyses using the Bonferroni Correction revealed significant differences between Experiment 4 (*M* = 4.64, *SEM* = 0.40) and Experiment 1 (*M* = 7.89, *SEM* = 0.49), Experiment 2 (*M* = 7.48, *SEM* = 0.49), as well as Experiment 3 (*M* = 8.02 *SEM* = 0.40). The ANOVA revealed no interaction of context condition × experiment number $F(3, 216) = 0.28$, $p = .84$, $\eta_p^2 = .004$.

These results suggest that the failure to find an effect of physical context change in the individual experiments presented in this study were not due to a small sample size in each experiment. Also, the significant difference in recall between the experiments suggests that the failure to find a context effect was not due to level of recall in each experiment. This may instead reflect a difference in type of experimental paradigm used. The mean level of recall in Experiments 1 to 3 which used the reinstatement paradigm were closest to each other, and were higher than those found in Experiment 4 which used an interference paradigm. Furthermore, the non-significant trends in means being more similar to those expected from context effects were most notable in the first three experiments than the fourth one, indicating that the reinstatement paradigm may be a better way to test for context effects than the interference paradigm.

Although results suggest that the sample sizes used here were relatively adequate, a post-hoc analysis using G*Power 3.1 (Faul, Erdfelder, Lang, & Buchner, 2007) was performed to identify the actual number of needed participants in order to find an appropriate level of power. Using the average effect size of d = .28 or f = .14 (Cohen, 1988) as calculated by Smith and Vela (2001) in their meta-analysis for context effects, along with an α = .05, N = 495 participants would be required for the study to reach a power of .80. This number is quite large, but is likely due to the small effect size found across context studies. Were the effect size instead a medium size of d = .50, the same power analysis indicates only 159 participants would be needed to attain a power of .80. Therefore, although the number of participants in this study was deemed reasonable for the researcher to conduct in the given time, and the cumulative analysis indicates that something other than small sample size may be contributing to the absence of context effects, we cannot deny that the study would benefit from a larger sample population. Overall, it may be the case that small effect sizes, which are expected, made context effects difficult to detect. Also, some factors may have interacted in ways that do not promote context effects and thus warrant a deeper investigation.

Chapter 7: General Discussion

It is puzzling as to why the seemingly robust phenomenon of context-dependent memory was not demonstrated in any of the four experiments carried out in this study. It was initially assumed that an effect of physical context would be found in the first experiment and so the second was designed to look at an interesting aspect of imagined contexts, self-relevant imagined contexts. We were hoping to be able to add to literature regarding the usefulness of imagined reinstatement as a way to aid memory, as mental reinstatement has shown to be beneficial in areas such as eyewitness memory and could also help with aging, education and clinical applications. Examining self-relevant imagined contexts had to be suspended however, as basic context effects, not just those of mental reinstatement, but of physical reinstatement, were not revealed.

Experiments 2 and 3 were encouraging because although non-significant, mean number of words recalled in same context groups tended to be higher than different context groups. Experiment 3, where extra efforts were put forth to make the same and different contexts very distinct and the imagined context quite salient, had the highest overall level of recall among the other experiments. This suggests that some participants may have been benefiting from environmental context cues, but not enough that there was a significant effect of context. Experiment 4 had the most consistent level of recall among all groups, demonstrating that contextual cues were the least important to the same and different context groups.

Experiment 4 also demonstrated that even when there is interfering information, participants are still able to identify individual words and parcel lists apart when there is a change in context. The utilization of the interference paradigm in this fourth experiment also seemed to highlight the non-significance of physical environmental reinstatement as compared to mental reinstatement. As in Smith's 1979 study where he instructed different context participants to mentally reinstate their previous learning environment, we asked different context group participants to do the same in the DC condition. We further predicted that the SC group would have done even better due to receiving the same mental reinstatement instructions while also being in the same physical environment instead of a different context. DC group participants may have found it more challenging to mentally reinstate the context when physical cues were not apparent. However, seeing that both groups performed equally as well, this could mean that mental reinstatement is still an effective method to enhance recall but that physical reinstatement is not necessary to facilitate memory.

An interesting consideration is one in which we compare the current study to those of classroom studies that found no effect of context on recall. In these studies, students who were tested in a classroom or training environment different from that at study found that context did not have an effect on their ability to remember information. This was the case whether it was related or unrelated to their school studies (Saufley et al., 1985; Koens et al., 2003; Conveney et al., 2013). Several reasons were advanced on why this may be the case, and why students did not seem to processes or utilize environmental information during encoding and test.

Most notably, decontextualization in these classroom studies may have occurred due to students using their own self-generated memorization techniques. Students, the participants in this study, are very adept at learning and test taking in school environments. Rote memorization of material is a particularly simple task that students have likely developed quick mnemonics for and use frequently while learning. They may even have viewed this experiment as just another school test, and behaved much the same as they would in that type of situation. The reliance on their own techniques would detract from using the environment as an effective cue, and thus context effects would be absent. Participants in this study did mention using their own methods to learn the study words, often expressing that they were unaware of the global environment and did not make conscious associations between the words and the physical environment.

Although it was intended that context be global in nature, in the fourth experiment we moved to a more local manipulation of context, where we asked participants to directly include the environment in their study of the words. Participants may still have ignored the local context or found it difficult to both memorize words while ‘using the context to help their memory’. They may also have not understood what this instruction meant. In Eich’s (1985) study of context, he asked participants to directly associate words with specific objects in the room in a manipulation of local context. This was intended to make recall reliant upon the objects as environmental cues, however, context effects were also absent. Therefore, although local manipulations of context may seem more likely to show context effects, such as in studies of recognition (Hockley & Bancroft, 2015), it is unsure how the same applies to recall.

Future examinations may include the type of procedures and contexts that best elicit context effects. Type of context or encoding instruction may make up part of the reason why context effects are found in some studies but not in others. For example, in Experiment 2, we predicted that self-relevant imagined contexts may enhance the benefits of common imagined contexts. While self-relevant information is generally remembered better than other types of information (Symons & Johnson, 1997), they do not always lead to context effects. McDaniel et al. (1989) demonstrated that when participants were asked to encode sentences in a self-referential manner, context effects were absent. Participants learned nouns embedded in common or bizarre sentences (e.g. *"The DOG rode the BICYCLE down the STREET"*) and either related the information to some event or object in their lives (self-referential) or simply rated the information on it's level of normalcy while in one physical context. Upon switching contexts, only participants who did not use the self-referential encoding method showed context effects. The authors attribute this to the fact that self-referential encoding may induce the participants to use internal organizational processing instead of contextual information, thus negating the context effects. Although this may account for the reason why context effects were not seen in the SRIC group of Experiment 2 in this study, they do not seem to make sense of the fact that there was no basic context effect seen with the different physical context group.

The absence of context effects was also found when participants were asked to encode sentences using visualization of the nouns by imagination and when asked to organize sentences by their relation to one another (McDaniel et al., 1989). Type of processing used when encoding also seems to extend to shallow or deep processing, where shallow encoding encourages context effects more than deep encoding (Smith, 1986). Type of context may also affect whether context effects are found. It seems to be that artificial environments, such as those created on the computer using pictures or photos and even virtual reality, show robust context effects. In fact, Smith and Manzano (2010) found particularly strong context effects when using video clips as environmental contexts. Participants learned words superimposed on 5-second videos depicting natural scenes. Those who experienced reinstated environments at test remembered many more words than those in the different context condition. Clearly, type of context then, whether it be video or photo, seems to impact how individuals remember information. Overall, strategies that seem to encourage participants to use internal organizations or elaborative encoding decontextualize relevant cues from the environment. Type of context also seems to play a role, however, in which ways they influence memory still warrants more investigation.

Forgetting information after a change in context goes hand in hand with reinstatement. We are likely familiar with the occurrence of these phenomena – we stand staring at an open fridge forgetting what we wanted, only to have it come to us when we are back in the other room. We visit old schools for class reunions and memories from our school years come flooding back. Although we are aware that these instances occur, they are not as reliable when attempting to elicit them in the laboratory. Recall seems to be improved by a variety of factors, such as imagery, self-referential encoding methods, and repetition of material for example, but how context influences these factors is less reliable. Also, type of context, whether imagined or physically present, pose challenges for understanding both encoding and retrieval of desired information. If we can ultimately find a way to maximize beneficial properties of encoding and retrieval environments, then surely memory will improve upon context reinstatement.

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Tables

Table 1

Experimental design for Experiments 1, 2, 3, and 3b with imagined context (yes or no) and environmental contexts Lab (A), Office (B), and Atrium (C) for all study groups during list learning and recall

		Task		
Experiment Number	Context Condition	Imagination	List learning	Recall
1	SPC	No	A	A
	DPC	No	A	B
	SIC	Yes	A	B
2	DPC2	No	A	B
	SIC2	Yes	A	B
	SRIC	Yes	A	B
3	SPC3	No	A	B
	DPC3	No	A	B
	SIC3	Yes	A	B
3b	DPC3b	No	A	C

Note. See individual experiments for names of each context condition group.

Table 2

Mean number of words recalled (strict and lax criteria) and number of intrusions in Experiment 1, for context conditions same physical context (SPC), different physical context (DPC) and same imagined context (SIC)

	Context Condition		
Criterion	SPC	DPC	SIC
Strict Recall	6.69 (4.45)	6.94 (2.98)	7.44 (3.01)
Lax Recall	7.75 (4.28)	7.81 (2.93)	8.19 (2.90)
Intrusions	0.69 (1.25)	1.31 (1.35)	1.00 (0.90)

Note. Standard deviations presented in parentheses.

Table 3

Mean number of words recalled (strict and lax criteria) and number of intrusions in Experiment 2, for different physical context 2 (DPC2), same imagined context 2 (SIC2) and self-relevant imagined context (SRIC) context conditions

	Context Condition		
Criterion	DPC2	SIC2	SRIC
Strict Recall	6.44 (2.58)	7.38 (3.18)	6.85 (3.11)
Lax Recall	7.19 (2.88)	8.25 (3.28)	7.31 (3.46)
Intrusions	0.69 (1.01)	0.50 (1.03)	0.56 (0.81)

Note. Standard deviations presented in parentheses.

Table 4

Mean vividness ratings on a scale from 1 (unclear) to 5 (clear) at three times (beginning, middle, and end) of word list presentation for imagination groups SIC2 and SRIC in Experiment 2

	Scale Presentation Time			
Context Condition	Beginning	Middle	End	Average
SIC2	3.81 (0.66)	2.88 (1.03)	2.94 (1.00)	3.21 (0.52)
SRIC	4.13 (0.72)	3.31 (0.95)	3.00 (0.97)	3.48 (0.58)

Note. SIC2 = same imagined context 2 and SRIC = self-relevant imagined context. Standard deviations presented in parentheses.

Table 5

Mean number of words recalled (strict and lax criteria) and number of intrusions in Experiment 3, for context conditions same physical context 3 (SPC3), different physical context 3 (DPC3), and same imagined context 3 (SIC3)

	Context Condition		
Criterion	SPC3	DPC3	SIC3
Strict Recall	8.06 (3.28)	7.13 (2.92)	8.94 (4.30)
Lax Recall	8.19 (3.33)	7.19 (2.86)	9.13 (4.32)
Intrusions	0.63 (0.89)	0.69 (0.87)	1.19 (1.17)

Note. Standard deviations presented in parentheses.

Table 6

Mean number of words recalled (strict criterion) per level of recall (high – above the median, and low – below the median) for each context condition (SPC3, DPC3, and SIC3) in Experiment 3

	Level of Recall	
Context Condition	High	Low
SPC3	10.7 (2.32)	5.38 (1.06)
DPC3	9.50 (0.93)	4.75 (2.12)
SIC3	12 (3.46)	5.89 (2.48)

Note. Standard deviations presented in parentheses.

Table 7

Environmental contexts Office (B) or Lab (A) for list learning and recall tasks for context conditions same context interference (SCI), different context interference (DCI), different context (DC), and same context (SC) in Experiment 4

	Task		
Context Condition	L3	L4	Recall
SCI	B	B	B
DCI	B	B	A
DC	B	A	A
SC	B	A	B

Note. L3 = word list 3 and L4 = word list 4.

Table 8

Mean number of words recalled (strict and lax criteria) and number of intrusions for context groups same context interference (SCI), different context interference (DCI), different context (DC), and same context (SC) in Experiment 4

	Context Condition			
Criterion	SCI	DCI	DC	SC
Strict Recall	4.63 (3.95)	4.25 (2.11)	4.25 (2.21)	4.81 (2.48)
Lax Recall	4.81 (4.15)	4.31 (2.06)	4.31 (2.39)	5.13 (2.39)
Intrusions	1.13 (1.31)	1.00 (0.82)	2.13 (1.93)	1.81 (1.47)

Note. Standard deviations presented in parentheses.

Figures

Figure 1. Memory Laboratory cubicle used as one physical context environment.

Figure 2. Office, used as one physical context environment.

Figure 3. Mountain and pathway scene drawn from Hancock et al. (1992) used as the imagined context for group SIC in Experiment 1 and group SIC2 in Experiment 2.

Figure 4. Beach scene used as the imagined context for group SIC3 in Experiment 3.

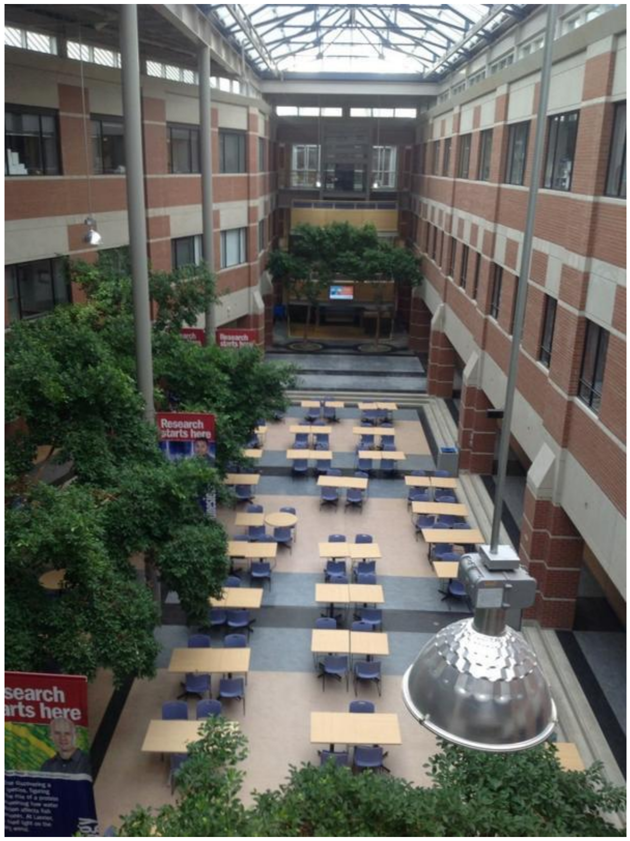

Figure 5. Science Atrium used as the different physical context in Experiment 3b for group DPC3b.

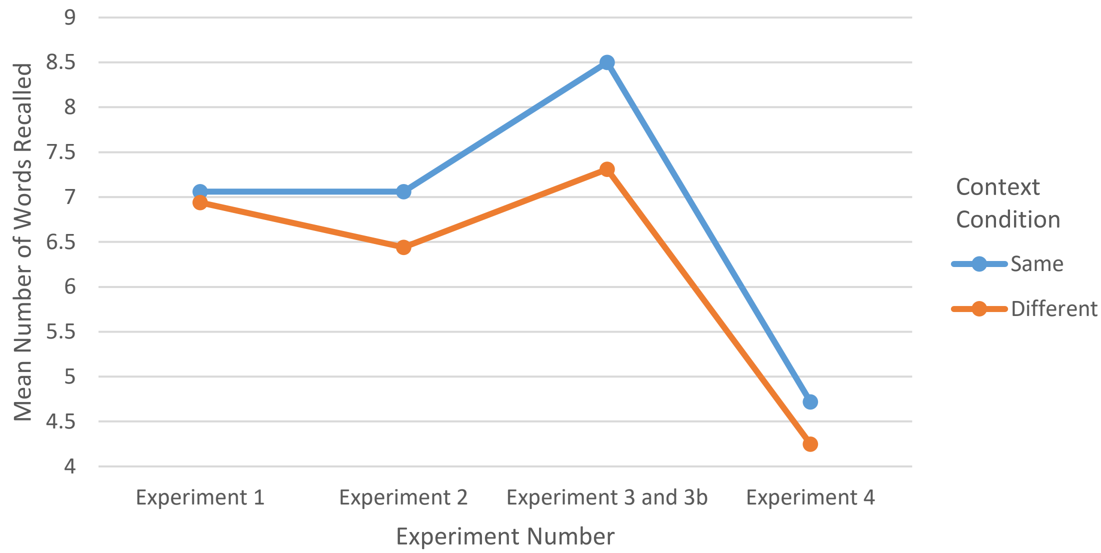

Figure 6. Average number of strict criterion words recalled in each context condition as a function of experiment number.

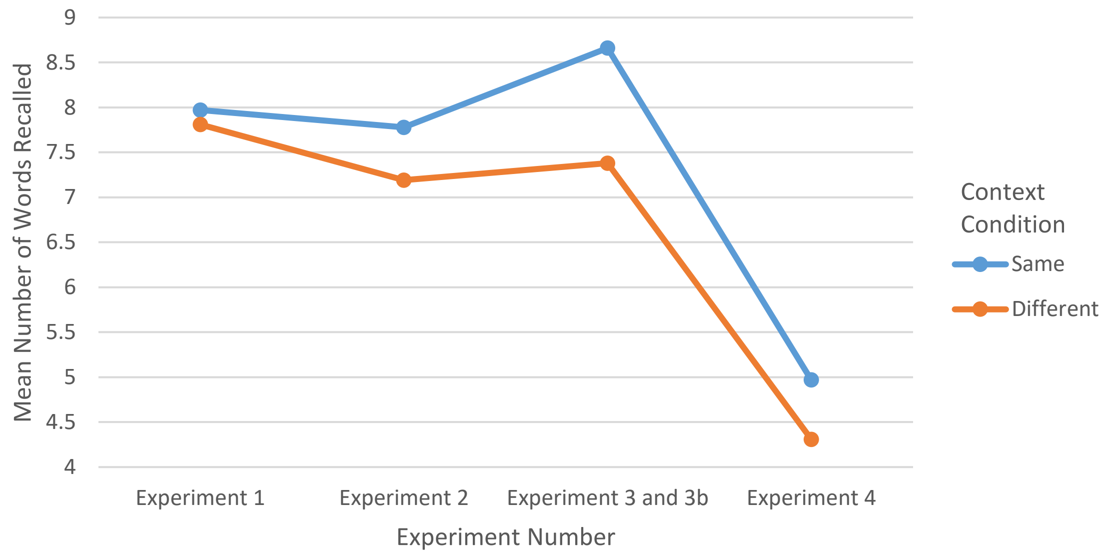

Figure 7. Average number of lax criterion words recalled in each context condition as a function of experiment number.

Appendix A

Informed Consent Statement

Wilfrid Laurier University
Informed Consent Statement

Free Recall and Scene Imagination during an Auditory Presentation of Words

Caitlin Tozios & William Hockley, Department of Psychology
Wilfrid Laurier University (REB # 4905)

You are invited to participate in a research study being conducted by Caitlin Tozios under the supervision of William Hockley of the Department of Psychology from Wilfrid Laurier University. The purpose of this study is to further research in memory and cognition by looking at scene imagination and recall for studied words.

INFORMATION

You will begin the experiment in the Memory Lab (SR212) where you will listen to a list of study words presented through headphones attached to a computer. You will also be asked to remember the presented words and also to follow some additional instructions presented on the computer screen. Some participants may be asked to imagine a scene or write down some information during the experiment. You may then be asked to move to an office (N2032) in order to complete a free recall task. The full purpose of this study cannot be disclosed at this time, but you will receive a full explanation at the completion of the study. The experiment will take approximately 20-30 minutes to complete and a total of 96 participants will be recruited through PREP to participate in this study. Each participant will be tested individually, one at a time.

RISKS

There are no immediate risks to be concerned about in this study, however you may find the recall task to be difficult. The task is designed to be difficult which is common in these types of memory studies, so please do not feel distress regarding your performance in this study. Any feelings of distress concerning performance are normal and should be temporary. If you experience any negative effects as a result of participating in this study, please contact the researchers.

BENEFITS

Results from this study will contribute to the scientific literature on imagination and free recall in memory and cognition. You will be able to gain practical experience by participating in an experimental paradigm that you may have come across in Introductory Psychology courses or Memory and Cognition courses on human memory.

CONFIDENTIALITY

All data gathered from this study will be stored electronically without any identifying information. Individual results will not be reported. Participants will be asked to provide their name and Laurier email address for the purpose of assigning PREP credit. This information will be collected and stored separate from the data and will be destroyed by the researchers after the PREP credit has been assigned (no later than March 31, 2017). At all times, only the researchers (Caitlin Tozios and William Hockley) will have access to the data. The anonymous electronic data will be stored indefinitely and securely in the researcher's locked lab and office. The data may be reanalyzed as part of a separate project (i.e., secondary data analysis). Consent forms will also be stored securely in the locked office and will be destroyed (shredded) by the researchers no later than March 31st, 2017.

Participant's Initials ________

COMPENSATION

By participating in this study you will earn 0.5 participation credit towards a component in your course grade. Alternatively, you may write a critical review of a journal for participation credit. Information about writing the review can be found on the WLU psychology department website under 'documents' or you may contact the Psychology Office for more details. If you decide to withdraw from this study prior to its completion you will still receive the participation credit and any information you supplied will be electronically deleted.

CONTACT

If you have questions at any time about the study or the procedures (or if you experience adverse effects as a result of participating in this study), you may contact the researcher, Caitlin Tozios, Department of Psychology, Wilfrid Laurier University, tozi4380@mylaurier.ca. You may also contact the researcher William Hockley, Department of Psychology, Wilfrid Laurier University, 519.884.0710, extension 3737, or whockley@wlu.ca. This project has been reviewed and approved by the Research Ethics Board at Wilfrid Laurier University (REB #4905), which is supported by the Research Support Fund. If you feel you have not been treated according to the descriptions within this statement, or your rights as a participant in research have been violated during the course of this study, you may contact Dr. Robert Basso, Chair of the Research Ethics Board, Wilfrid Laurier University, 519.884.0710, extension 4994, or rbasso@wlu.ca.

PARTICIPATION

Your participation in this study is voluntary and you may decline to participate without penalty. If you decide to participate, you may withdraw at any time without penalty and without loss of benefits to which you are otherwise entitled. If you withdraw from this study before its completion, any data collected will be electronically deleted. After completion of the study however, your data cannot be deleted because the data will be stored without any identifying information.

FEEDBACK AND PUBLICATION

You will be given information describing the purpose of this study and any further information at the end of this session. A summary of the findings of this study will be posted on the Psychology Research Bulletin Board and emailed to you via the PREP system by March 31st 2017. Results of this study could be submitted for publication to a cognitive psychology journal such as the Canadian Journal of Experimental Psychology, or Memory & Cognition, and may be made available through Open Access resources. The findings will be included in the researcher's Master's thesis.

CONSENT

I have read and understand the above information. I have received a copy of this form. I agree to participate in this study.

Participant's signature ______________________________ Date ________________

Investigator's signature ______________________________ Date ________________

Study Instructions for Experiment 1

The following are the study instructions which participants read on the computer or were orally instructed (italic text) by the researcher. Any information appearing in square brackets were events that occurred or actions completed by participants. All instructions were displayed after participants filled out some basic demographic information and signed the consent form.

Groups SPC, DPC and **SIC (bolded)**:

Please put on your headphones. Press the spacebar when you are ready to proceed.

The following is a tone that you will hear throughout the experiment. [Tone played]. This tone signals the end of a task. [Tone played]. If you need to stop the experiment you may do so after the tone. Please press the spacebar to proceed to the experiment.

You will see some simple math questions appear on the screen. Please type the correct answer into the box that appears followed by the 'enter key' in order to go to the next question. Press the spacebar to continue. **Please view the following image. It will remain on the screen for 2 minutes. When you see the image, take a moment to observe the scene before you close your eyes. With your eyes closed, imagine as though you are within the scene. When the task ends after 2 minutes you will hear a tone and you may open your eyes. Press the spacebar when you are ready.**
[~40 (2 mins) math questions appear, **image of mountain scene shown on computer**]
[Tone played]

A list of words will now be presented through the headphones. Please listen and remember these words. **While listening, imagine as though you are within the scene you just saw. It is important that you try your best to imagine a clear image while the words are being played. You may close your eyes, a tone will signal the end of this task.** When the task is finished, please exit the cubicle and speak to the researcher. Press the spacebar to proceed.
[List of words played]
[Tone played]
Please exit the cubicle and call the researcher to begin the next phase of the experiment.

[Participants move to the office (DPC and SIC) or stay in the Lab (SPC) while engaging in casual conversation with the researcher]

You will now be given 3 minutes to write down any words you can remember from before on the paper in front of you**. Before you complete this task, please re-imagine the scene from before that you were**

thinking of when you listened to the words. While writing any words you can remember, re-imagine that you are in the previous scene. Press the spacebar when you are ready to begin.
[Free recall task]
[Tone played]

[Experiment over]
Thank you, the experiment is now complete. Please speak with the researcher to collect the study information sheet and ask any questions you may have.

Study Instructions for Experiment 2

Group DPC2:

Please put on your headphones. Press the space bar when you are ready to proceed.

The following is a tone that you will hear throughout the experiment. [Tone played]. This tone signals the end of a task. [Tone played]. If you need to stop the experiment you may do so after the tone. Please press the spacebar to proceed to the experiment.

You will see some simple math questions appear on the screen. Please type the correct answer into the box that appears followed by the 'enter key' in order to go to the next question. Press the spacebar to continue.
[~100 (5 mins) math questions appear]
[Tone played]

A list of words will now be presented through the headphones. Please listen and remember these words. When the task is finished please exit the cubicle and speak to the researcher. Press the spacebar to continue.
[Fatigue scale presented at beginning, middle (after 10th word) and end of word list]
Please complete the following scale by typing the corresponding number.
How tired do you feel right now?

1 – exhausted
2 – tired
3 – neither tired nor energized (neutral)
4 – alert
5 – alert (energized)

[List of words played]
[Tone played]
Please exit the cubicle and speak to the researcher.

[Participants move to office, along the way engage in casual conversation with researcher]

Please put on your headphones. You will now be given 3 minutes to write down any words you can remember from before on the piece of paper in front of you. Press the spacebar when you are ready to begin.
[Free recall task]
[Tone played]

You will again see some simple math questions. Type the correct answer into the box that appears followed by the 'enter' key in order to go to the next question. Press the spacebar to continue.
[~60 (3 mins) math questions appear]
[Tone played]

[Experiment over]
Thank you, the experiment is now complete. Please speak with the researcher to collect the study information sheet and ask any questions you may have.

<u>Groups SIC2 and **SRIC (bolded)**</u>:
Please put on your headphones. Press the spacebar when you are ready to proceed.

The following is a tone that you will hear throughout the experiment. [Tone played]. This tone signals the end of a task. [Tone played]. If you need to stop the experiment you may do so after the tone. Please press the spacebar to proceed to the experiment.

Please view the following image. It will remain on the screen for 1 minute. When you see the image, take a moment to observe the scene before you close your eyes. With your eyes closed, imagine as though you are within the scene. **You are asked to construct an imagined location in your mind. Please think of a place that is familiar to you, somewhere you visit often, or a personally meaningful area. For example, you may imagine a room in your house (bedroom, kitchen), a room you go to at school (library, gym), somewhere you visit outdoors (park, garden), or a place you have been for vacation (beach, cottage, city street). Press the spacebar if you understand.**
When you have thought of a location that is important or familiar to you, please vividly imagine yourself in this place. Take note of things and objects you can see in this place and any sounds or smells that may be present. You will be given some time to close your eyes and imagine your place fully and clearly after these instructions. When this task ends, you will hear a tone and you may open your eyes. Press the spacebar when you are ready to begin the imagination task.
[Mountain scene displayed for 1 minute, **imagine scene**]
[Tone played]

Now you will be given 3 minutes to write a descriptive paragraph about the scene you just imagined. Please write down any details about the scene on the piece of paper in front of you. You do not have to worry about paragraph structure, spelling or completeness. **For example you may write: 'The scene I imagined was my bedroom. In my room there is a bed on the far left wall and a desk adjacent to it. My bedspread has a print of multiple small pink flowers on a white background. Often it smells of vanilla when I light a candle in the room…'** Press the spacebar when you are ready to continue.
[Write paragraph]
[Tone played]

Take this opportunity to again imagine the same scene as you have just described. Close your eyes as you imagine the scene, a tone will signal when you may open your eyes. Press the spacebar to begin.
[Imagine scene for 1 minute]
[Tone played]

A list of words will now be presented through the headphones. Please listen and remember these words. While listening, imagine as though you are within the **personal** scene that you just imagined as

you remember the words. It is important to try your best to imagine a clear image while the words are being played. When the task is finished please exit the cubicle and speak to the researcher. Press the spacebar to proceed.
[Vividness scale presented at beginning, middle (after 10th word) and end of word list]
Please complete the following scale by pressing the corresponding number on the keyboard.
How vivid/clear is your imagined environment at this time?

1 – not vivid at all (unclear)
2 – vaguely vivid
3 – neither clear nor unclear
4 – mostly vivid
5 – very vivid (clear)

[List of words played]
[Tone played]
Please exit the cubicle and speak to the researcher.

[Participants move to office, along the way engage in casual conversation with researcher]

Please put on your headphones. You will now be given 3 minutes to write down any words you can remember from before on the piece of paper in front of you. Before you complete this task, please re-imagine the scene from before that you were thinking of when you listened to the words. While writing any words you can remember, re-imagine that you are in the previous scene. Press the spacebar when you are ready to begin.
[Free recall task]
[Tone played]

Please write another short paragraph describing your imagined scene as it appears currently in your mind. Again, do not worry about paragraph structure, spelling or completeness. Also, you do not need to worry about providing new details; it is fine to repeat information as long as what you write accurately and fully describes your imagined scene. Please press the spacebar to begin.
[Type paragraph]
[Tone played]

[Experiment over]
Thank you, the experiment is now complete. Please speak with the researcher to collect the study information sheet and ask any questions you may have.

Study Instructions for Experiment 3 and 3b

Groups SPC3, DPC3, **SIC3 (bolded)**, and DPC3b:

Please put on your headphones. Press the space bar when you are ready to proceed.

The following is a tone that you will hear throughout the experiment. [Tone played]. This tone signals the end of a task. [Tone played]. If you need to stop the experiment you may do so after the tone. Please press the space bar to proceed to the experiment.

You will see some simple math questions appear on the screen. Please type the correct answer into the box that appears followed by the 'enter key' in order to go to the next question. **Please view the following image. It will remain on the screen for 2 minutes. When you see the image, take a moment to observe the scene before you close your eyes. Notice any details, colours or sights that you would experience were you actually in the scene. What do you smell? What can you feel? With your eyes closed, imagine clearly as though you are within the scene. When the task ends after 2 minutes you will hear a tone and you may open your eyes.** Press the space bar to continue.
[~40 (2 mins) math questions appear, **beach scene displayed**]
[Tone played]

A list of words will now be presented through the headphones. Please listen and remember these words. **While listening, imagine as though you are within the scene you just saw. It is important that you try your best to imagine a clear image while the words are being played. You may close your eyes; a tone will signal the end of this task.** Press the space bar to proceed.
[List of words played]
[Tone played]

Please view this image again and keep it in your mind as you proceed to the next part of the experiment.
[Black screen displayed, **beach scene displayed** for 5 seconds]

The list of words you heard earlier will be repeated again. Please listen and remember these words **while imagining yourself in the scene you just saw**. Press the space bar to continue.
[Words played]
[Tone played]

Please exit the cubicle and call the researcher to begin the next phase of the experiment.

[Participants remain in the Lab (SPC3), move to the office (DPC3, and SIC3) or the Atrium (DPC3b) for the recall task, instructions given orally for group DPC3, SIC3, and DPC3b]

Take 2 minutes to again complete some simple math questions. Press the space bar to begin. ***Take 2 minutes to write down details about the scene you imagined before on the piece of paper in front of you. They can be in point form. I will let you know when time is up.***
[Tone played]

Please type *(write down)* any words you can remember from before using the keyboard *(piece of paper in front of you)*. ***While writing down the words, use the imagined scene to help you remember any of the words.*** A tone will signal when the experiment is over *(I will let you know when time is up)*.
[Tone played]

[Experiment over]
Thank you, the experiment is now complete. Please speak with the researcher to collect the study information sheet and ask any questions you may have.

Study Instructions for Experiment 4

Group SCI, **DCI, DC and SC (bolded)**:

In this study you will be presented with two lists of words which we ask you to remember, however please keep these two lists separate. ***We are also interested not only in memory for words but memory for where or the place where words are learned. For example, you may find it easier to remember something your friend told you if you remember the place where they told it to you, such as in a coffee shop or at school where you visit frequently together or in a visually distinct place like a museum or colourful outdoor venue, than in a place where you two don't normally go to, or is dull and undistinctive. If the place is easy to remember, you would be more likely to remember the information as well. When you are listening to the words, keep in mind the visual aspects of this location as well.***

Sound test: you will soon hear a tone. Please put on your headphones and press the spacebar to proceed. [Tone played]Press the space bar if you heard the tone, if not, please alert the researcher.

You will now be presented a list of words, please listen and remember the words, press the spacebar to proceed.
[L1 played]
Thank you, please speak to the researcher for the next task.

Please complete this sheet of math questions, do as many as you can in 2 minutes. I will tell you when time is up.
[Math questions presented on paper for groups SCI and **DCI**]

[Groups DC and SC move to Office]

The second word list will now be presented, ***before the next list is presented, please remember that memory for the place in which these words are important as well, and to keep this place in mind.*** Press the spacebar to proceed
[L2 played]
Thank you, please speak to the researcher for the next task

[Group DCI moves to office, group SC returns to the Lab]

Please complete this connect-the-dots exercise and complete as much as you can in 2 minutes. I will tell you when time is up.
[Connect-the-dots exercise presented on paper for group SCI and **DC** only]

I will now give you 3 minutes to write down any words you can remember from the first list. ***Try to remember where you were when you first studied the words in the first list. Thinking about where you were may help you to remember the words.***
[Free Recall of L1]

[Experiment over]

Appendix B

Word List 1 (L1)

Monster	Beggar	Estate	Picture
Thunder	Jewel	Butcher	Column
Cherry	Traitor	Paper	Question
Sailor	Echo	Village	Model
Summer	Survey	Hotel	Costume

Word List 2 (L2)

Shower	Metal	Writer	Series
Feather	Pilot	Chapel	Ribbon
Widow	Outline	Poem	Goddess
Attack	Agent	Letter	Meaning
Notion	Lady	Contest	Harness

Word List 3 (L3)

Hotel	Jewel	Attack	Monster	Chapel
Widow	Summer	Sailor	Traitor	Pilot
Outline	Letter	Goddess	Contest	Notion
Paper	Model	Question	Costume	Village
Series	Echo	Agent	Butcher	Lady

Word List 4 (L4)

Climate	Baby	Basin	Bushel	Leather
Feeling	Event	Dinner	Island	Meeting
Prayer	Payment	Mistake	Oyster	Single
Steamer	Soldier	Servant	Robber	Bubble
Worship	Wagon	Winter	Chairman	Pasture