How processing of background context can help memory for target words in younger and older adults

by

Harm Kelly

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Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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Abstract

We examined how explicit instructions to encode visual context information accompanying visually-presented unrelated target words affected later recognition of the targets presented alone, in younger and older adults. In Experiments 1 and 3, neutral context scenes, and in Experiments 2 and 4, emotionally salient context scenes, were paired with target words during encoding. Experiments 1 and 2 data were collected using within subject design; in Experiments 3 and 4 we used a between subjects design. Across all four experiments, instructions to explicitly make a link (associate) between simultaneously presented context and target words always led to significantly better recognition memory in both younger and older adults compared to deep or shallow levels of processing (LoP) instructions for the context information. In all experiments the age-related deficit in overall memory remained. There was no consistent difference in the effect of a shallow versus deep processing of context in the first three experiments in young adults, although a standard LoP effect, with better memory performance following deep than shallow processing, was demonstrated with both age groups in Experiment 4. Results suggest that an instruction to explicitly link target words to context information will significantly and consistently improve memory recognition for targets. This was demonstrated in all four experiments, in both younger and older adults. Importantly, results suggest that memory in older adults can be improved with specific instructional manipulations during encoding.

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Chapter 1
General Introduction

1.1 Cognitive Aging and the Associative Deficit Hypothesis

Our ability to remember the past, to keep track of those we come in contact with, and to learn new ideas is at the core of our identity as individuals. Viewing popular media representation or Hollywood movies about those who have lost their memory, and consequently have reduced abilities to remember, paints a poignant picture to us as to how different our lives would be without the ability to form memories and how much we often take for granted our everyday cognitive abilities. Most of us will have to find out what it is like when we get older, and almost everyone has witnessed these effects of aging on memory in their grandparents or parents, from the gradual inability to remember appointments and family events to not being able to remember people`s names in social settings to, in extreme cases, forgetting who people are altogether.

As many may well know when talking with grandparents or older parents, it often is observed how they increasingly tend to forget everyday items, like appointments, picking up items on a shopping list, or even where they parked the car when they go shopping. Sometimes they may also comment that they do not remember new people they have met anymore, even if it was recently, or know that they know someone but cannot remember their name or where they know them from. In all of these cases, it is easy to see how these everyday lapses in memory can be a source of concern, of stress and often of embarrassment on the part of the seniors. Several years ago, I encountered my elderly neighbor who was in her mid-eighties while I was running some errands. She was obviously distraught and when I asked what was the matter she told me her car was missing, and that it had been stolen. I checked up and down the street with her, and after we were unable to locate her car, she then called 911 and reported her car stolen to the police. They sent a squad out to meet her, and apparently the officers have had this happen more often to them with seniors, because rather than also assume it was actually missing, the two police officers noted the license plate number and description of the vehicle from my neighbour and searched further around where the senior had reported to have been shopping, and found her car parked in another nearby parking lot behind the store. As you could imagine, she was seriously embarrassed at this very public lapse in memory, and in the meantime, it also took up two police officers' time and resources for nearly an hour.

Since relatively early on in the field of memory research, age differences have been demonstrated in laboratory type memory tasks as well. First it was thought that only recall was affected substantially by aging (Schonfield & Robertson,1966; Harwood & Naylor, 1969), and that recognition was retained relatively intact, since recall tests required the participant to resupply the items memorized whereas recognition memory test supplied the items and merely required an identification to indicate memory (Schonfield & Robertson, 1966; Kapnick, 1971). However, as older adults began to be studied more closely, with older seniors (62+ yrs) included in research studies, it became apparent that recognition memory also is susceptible to the effects of age (Erber, 1974), with greater age differences being demonstrated with more complex recognition tasks and with longer lists for retrieval, as well as greater age differences the longer the delay between encoding and retrieval.

As the brain ages, there are numerous changes that occur within the brain which are the underlying cause for these increases in lapses of memory, as well as increasing difficulty in other types of tasks as well. These changes include the reduction in axonal integrity throughout the networks across the brain and the decrease of gray matter, white matter hyper intensities, de-differentiation, reduced lateralization, and activation of compensatory regions (Charlton et al. 2009, Charlton et al. 2009; Minati, Grisoli, and Bruzzone, 2007; Cabeza et al. 1997). One of the main areas of study with age-related deficits is how to better understand exactly what these deficits are and what their underlying cause is, the good being to better understand the human brain as it ages and to design better strategies to help older adults compensate for these increasing memory dysfunctions.

In an effort to describe the processes involved that cause older adults to perform more poorly on a large range of cognitive measures, Salthouse (1996) proposed his processing speed theory of adult age differences in cognition. He argued that as the brain ages, the neurological changes that accompany age result in slowed mental processing speed and, since many cognitive measures are time sensitive, this leads to a decrease in performance. Also, with the delay in mental processing, products of earlier processing may no longer be available to later processing, resulting in the lack of simultaneity of mental processes which would also lead to more errors.

In his groundbreaking study, Cabeza (1997) demonstrated that young adults exhibit unilateral brain activation during a memory task, whereas older adults activate more regions by exhibiting bilateral activation of brain regions. This has been explained as the aging brain`s natural compensatory mechanism and referred to as the HAROLD (hemispheric asymmetry reduction in older adults) model. Follow-up studies further clarified this finding, revealing that some older adults are able to complete cognitive tasks nearly as well as younger adults, whereas others struggle significantly in their cognitive performance. These studies found that older adult who performed the best typically had less hemispheric asymmetry and more bilateral activation, whereas those adults who performed poorly still exhibited unilateral activation, similar to the younger adults (Cabeza et al. 2002). This demonstrates that the aging brain is capable of adapting to maintain cognitive performance, although for some older adults this adaptation does not happen for some reason.

Although the processing speed theory does explain a large degree of the variability in the older adults' memory literature, there is more to the age-related deficits in memory performance. As important as processing speed is, it is also argued that the ability to bind different features of a memorial experience together, so that at retrieval they are still associated with each other (Chalfonte & Johnson, 1996), is also critically important to enable retrieval of details surrounding the event in the past. In a series of studies, Chalfonte and Johnson (1996) had both older and younger adults memorize pictures set in an array, and remember either one of the features (item, colour, or location) or a pair of features (item and colour or item and location). Through this, they demonstrated that although memory for separate features of items is sometimes impaired with older adults (memory for location in older adults is poor, but memory for item and colour information was equivalent to that of younger adults), the more common finding is that, when two features are encoded together, older adults are unable to perform well remembering the two features together (particular colour in a particular location).

This idea was elaborated by Naveh-Benjamin (2000). He conducted a series of studies to investigate what he termed the 'associative deficit hypothesis' in older adults. He hypothesized that a major aspect of the documented poorer episodic memory performance in older adults is due to their increasing difficulty in creating and retrieving links between single units of information in a memory at encoding and during retrieval. These ‘units’ can be any two aspects of a memory, be it the item and context, two context elements, or even a representation of two mental codes. Furthermore, the more a memory paradigm relies on the creation and/or use of these links between memory ‘units’, the greater the deficit in performance will be for the older adults (Naveh-Benjamin, 2000). He demonstrated in a series of experiments that older adults, both when incidentally and when intentionally encoding information, showed persistent deficits in remembering sets of associated items compared to individual items, even when they were told that they were going to be tested on in the memory for the sets.

In relation to an earlier observation by Hasher and Zacks (1979), who stated that information that is common in the environment to the item and useful to remember is automatically encoded with the item, it would seem that younger adults spontaneously form and utilize these associations, whereas older adults exhibit a reduced ability to engage in the forming of and consequent use of associations, at least automatically and spontaneously.

Recent research in our laboratory has investigated this effect and demonstrated that when older adults are specifically instructed to form associations between the item and the context, they are able to do so, and if that association is used again at retrieval, memory performance in older adults is significantly improved (Skinner & Fernandes, 2009; 2010). The purpose of this thesis was to determine whether an associative encoding instruction is the best memory encoding instruction, or whether there are other encoding instructions, particularly focusing on the contextual details surrounding the target item, that would yield better memory performance in both younger and older adults. If we can demonstrate novel ways to help improve memory, especially in older adults, these can be utilized to help remediate memory deficits which may interfere with day to day functioning on older adults' lives.

1.2 Context Effects on Memory

When we think of what a memory is, it is never a single item, but a holistic recreation of the original event with varying degrees of detail. There is a theory that memory derives from our need to cognitively maintain an ongoing mental representation of our environment (Glenberg, 1997).

Early research into how we remember what has happened to us led to the realization of the context reinstatement effect, demonstrated in a classic study by Godden and Baddeley (1975). Two sets of scuba diving participants learned study word lists either on land or in the water. It was demonstrated that memory performance was significantly improved by having the same environmental context present at retrieval as was there at initial encoding. An ecological example of how this can lead to a memory conundrum many of us have faced in everyday situations was described in a research paper by Mandler (1980), in which he investigated the role of context and familiarity on memory retrieval mechanisms. For example, you may know who your butcher is quite well, and see him on a regular basis in his butcher shop, but when you happen to encounter him in another setting, for example on a public bus, you might have a striking sense of familiarity, but cannot place how you know him, since the context you normally associate with the butcher has become part of your memory of who he is. However, you would have no problem identifying him in the same context you grew to know him, in the butcher shop.

This would be an example of a switched context, where memory can be impaired, as opposed to the benefit of having the same context present benefiting memory (context reinstatement).

However, as a review of the context reinstatement research has revealed, environmental context reinstatement effects can be dependent on the type of task that is used, with robust effects being consistently found when the type of memory test given requires recall, but little or no effect on memory performance in a recognition memory task (Smith, Glenberg & Bjork, 1978; Smith & Vela, 2001). In some situations, using the environmental context may assist in later memory retrieval, as in novel or emotional events, whereas in other situations it is conceivable that utilizing environmental context may actually hinder memory retrieval, as when the context is very mundane or very familiar or repetitive (Smith & Vela, 2001). It has also been demonstrated that although the same pattern of context effects is present in younger and older adults, an encoded event is less modified by the context in older adults (Craik & Byrd, 1982).

One way which attention can be focused and modulated during a memory task is to use emotional items or context. When emotional items are used in an item-context paired memory paradigm, memory performance is increased compared to neutral items, and the same effect occurs when aspects of the context are emotional, and this effect is the same for both younger and older adults (Davidson, McFarland, & Glisky, 2006). A possible mechanism for this is that emotionality is more novel than neutrality, and the novelty makes it easier to recall and dissociate from other events in memory.

When we try to piece all of these different aspects together we try to come up with a model or theory of how and why this works in the brain, often using analogies or comparisons.

The temporal context model (Howard & Kahana, 2002), described using an analogy of travelling down a road and looking backwards at telephones poles which have been passed, incorporates two important theoretical aspects of memory retrieval. The first is that our memory systems are able to recreate or reinstate previous contextual experiences, similar to jumping back to a telephone pole on the road behind us, with the more recent memories being easier to distinguish than those which are further back along the road of time. The second concept is the idea that the search for memories is driven by the temporal clusters and associated features of the item or event that was memorized, which serve as the telephone poles, and then the search for specific items can be carried out in the same general 'cognitive' vicinity, once the associated features and temporal clusters have been identified. This would indicate that the more useful the context information available and the better it is memorized, the more processing will speed up and make more efficient the route of retrieval.

Traditionally, when context effects are tested, there is the manipulation of same vs. different context between encoding and retrieval. Recent work in our lab, however, identified that even simply having meaningful context present at encoding, without reinstating a context at retrieval, confers a measurable benefit of having meaningful as opposed to meaningless context information available at encoding (Skinner & Fernandes, 2009). This effect is explained as the ability for younger adults to spontaneously engage in associative mechanisms to link target items with context during encoding, and this aids in retrieval later on. Using the telephone pole analogy, this is similar to making the telephone poles of the past road more distinctive and easier to find for later memory performances. Older adults, in contrast were not able to show the same benefit of having meaningful context present as younger adults, unless they were specifically instructed to attend to the context in relation to the target words (Skinner and Fernandes, 2009). In that study older and younger adults were presented with target words lists, presented one word at a time, either paired with weak contextual background (blank rectangles) or relatively rich contextual background (pictures of faces). Overall, memory for the words was better if they were presented with the rich compared to the weak contexts during encoding, even though these contexts were unrelated to the target stimuli in each trial. In the current thesis, I investigate the effect of encoding instructions when these are directed specifically toward the context information. That is, I examine the effect of different encoding instructions for the context information on later memory for target words, presented concurrently with the context at encoding.

1.3 Associative Memory

Very recently, a study was reported by Luo, Hendriks, and Craik (2010) in which young and older participants were given at encoding either a picture, a sound effect associated with a target item, or a condition requiring the generation of an association on the part of the participants. Results following these manipulations indicated that there are age differences in later memory for targets, depending on the type of encoding manipulation used; providing pictures during encoding of target information assisted older adults' later memory for targets more so than they did for younger adults. Generation helped both age groups equally, but only the younger adults showed a benefit of having a sound effect paired with targets at encoding. Recent work has also demonstrated that the mere presence of meaningful context information that is entirely unrelated to the target words also boosts later memory for targets in young adults (Luo, Hendriks, & Craik, 2007; Skinner & Fernandes, 2009, 2010). Asking participants to actively form associations between the context and the target item, however, boosted memory performance further still (Skinner & Fernandes, 2009). In both of these studies, memory was improved by the presence, and encoding, of context information, *even though* that same context information was not provided again during the memory test.

1.4 Levels of Processing Effects

One of the most common strategies that is taught to improve memory in undergraduate classrooms is the idea of levels of processing, and the well known benefit of 'deeply' encoding information to remember it better. Since early on in the field of psychology, there have been many different approaches and strategies used to actively improve memory performance, and one of the most influential psychological papers in the 20th century was the publication by Craik and Lockhart (1972), describing a proposed framework for the study of memory referred to as levels of processing (LoP). This framework proposes that memory retention is a function of depth of processing, and that various factors, such as the amount of attention devoted to a stimulus, its compatibility with the analyzing structures, and the processing time available, will determine depth of mental processing (Craik and Lockhart, 1972). Craik and Lockhart (1972) identified three general types of categories of processing in standard studies involving the memory for words, namely 1) structural, or a shallow type of processing which examines only the perceptual features of the stimuli (e.g., does this word have the letter "G" in it?), 2) phonemic, a moderate depth of processing on how a word sounds (e.g. does this word rhyme with ________), and 3) semantic processing, by stimulating deep processing into the meaning or interpretation of the word (e.g. is this word pleasant or not?). When such encoding questions are used, the general LoP effect is that the deeper the relative level of processing engaged in at encoding, the better memory performance will be.

Soon after the presentation of the LoP framework, the effect of these encoding manipulations was compared in young and older adults, revealing that the same general LoP effect occurs for both age groups, despite a general reduction in overall memory in old compared to young (Eysenck, 1974; Craik, 1977; Craik & Byrd, 1982). Although the original LoP effects were first demonstrated using words , the effect has also been demonstrated using various other stimuli, such as with voices (Goldinger, 1996), and with faces (Marzi &Viggiani, 2010; Troyer et al. 2006). This effect has also been demonstrated in recognition memory tests (Craik & Tulving, 1975), perceptual (Challis & Brodbeck, 1992) and conceptual implicit memory tests (Hamann 1990, Srinivas & Roediger, 1990), and explicit memory tests other than recall tests (Jacoby & Dallas, 1981).

Psychophysiological research soon demonstrated measurable physiological differences which correspond to the different types of memory performance with the varying levels of processing. Heart rate and galvanic skin conductance differ as a function of shallow, moderate and deep levels of processing conditions (Cohen & Waters, 1985). Kapur et al. (1994) demonstrated in a PET study that different encoding strategies in a memory task activate different regions of the brain. Electrophysiological recordings have also been shown to vary as a function of levels of processing in the memory task (Sanquist et al, 1980; Hamberger and Friedman, 1992). In summary, not only are levels of processing effects able to be demonstrated behaviorally in multiple types of memory testing paradigms, it can also be demonstrated that these types of encoding strategies activate the brain and other physiological systems in different ways as a function of the types of encoding being utilized.

1.5 Goals of the Current Thesis

There were a series of related questions that the current thesis sought to investigate.

1) Can the active encoding of meaningful context information benefit later item memory?

Previous research conducted in our laboratory demonstrated that when both older and younger adults are presented with meaningful context information (faces), memory performance for target words presented concurrently during encoding is enhanced even if the context is not shown again at retrieval memory (Skinner & Fernandes, 2009). We wished to extend these finding by utilizing picture of objects and scenes as meaningful context information, rather than faces, and actively encouraging the encoding of the context, but yet still testing memory for the target words. We wished to use context items which were ecologically valid, and it since the perception and memory of faces is a unique process activating the fusiform face area, we decided to avoid using faces as stimuli since findings related to face memory may not be generalizable to memory for other types of stimuli. The goal was to examine whether meaningful encoding of context information can help improve memory for target information, and to determine whether this effect differs in older and younger adults.

2) Would both younger and older adults show a further memory benefit if an associative instruction to actively link context to target items was given?

Previous work in our laboratory as well as in others has examined the benefit of encouraging the formation of associations between the target items being memorized. Would a similar benefit still occur if they were encouraged to form associations between the target items and the context in which these are presented? This would lead to a better understanding of how context information can be meaningfully processed to potentially assist in memory performance.

3) Would an associative encoding instruction lead to better subsequent memory relative to a deep LoP of the context information alone?

One of the most useful aspects of memory performance research is its ability to be used to help people improve their memory performance, and utilizing the LoP effect is a basic concept taught even in Introductory Psychology courses and well publicized in the public media. If an associative encoding condition is even better than a deep LoP, this may help lead to new applications to assist people in compensating for memory deficits. It is hypothesized that the administration of an associative encoding question will help to integrate the memory units together to make a cohesive unit, creating a richer representation of the target information, and that this encoding manipulation will work better than a much touted deep levels of processing benefit.

Chapter 2

Within-Subject Examination of the Effect of Encoding Context on Item Memory

2.1 Introduction to Experiment 1

It has previously been demonstrated that reinstating context information can aid in memory performance (Godden & Baddeley, 1975), and that even the mere presence of meaningful context information at encoding can lead to a boost in memory (Skinner & Fernandes, 2009). There were several purposes to this study. First, we wanted to extend the findings of previous work in our lab (Skinner & Fernandes 2009, 2010) which demonstrated that the mere presence of meaningful context information could lead to a boost in memory, to investigate if a further improvement to memory could be achieved by actively encoding the context information in various ways. A second reason was to investigate whether, in this type of encoding paradigm, an associative encoding instruction would lead to better memory for the item than a traditional deep encoding instruction. The benefit of the associative encoding condition was of particular interest, as it appears that associative memory is one type of memory that shows pervasive age effects and also has therefore the greatest potential to improve memory, since an instruction may aid older individuals in forming associations which they no longer do spontaneously (Naveh-Benjamin, 2000).

The unique aspect of the present approach is that previous memory research has primarily examined how different encoding manipulations related to the item being memorized impact later item memory performance, whereas in this experiment we manipulated the encoding of the context information, rather than the target item, in order to better understand how to utilize context effects to improve memory for target information.

For the first experiment, we investigated the effect of having an emotionally neutral image as background context information during presentation of target words, in both older and younger adults. We also investigated how three different types of encoding instruction, a shallow instruction, a deep instruction, and a condition requiring the generation of an association between the context and the item, for the context, influenced later memory for target information. Would a deep LoP of the context confer the same memory benefit as a deep LoP of the target?

We tested the hypothesis that a deep relative to shallow LoP encoding manipulation, even when conducted on the context information, rather than the target item, would result in better memory for target items on a later recognition test, in line with the standard LoP effect found by Craik and Lockhart (1972), but never tested in this manner. We also examined whether the magnitude of this benefit would be similar in younger and older adults.

We further hypothesized that an associative encoding instruction would lead to better item recognition memory than even a deep LoP encoding condition but that this relative benefit would be greater for the older adults. The associative deficit hypothesis suggests that the reason for the observed associative memory deficits in older adults is due to difficulty linking units of information at encoding, which they no longer do spontaneously as young adults do. Therefore, explicitly instructing them to engage in linking of target and context information is expected to provide a substantial memory boost, as similar findings have been demonstrated in other types of encoding paradigms (Skinner & Fernandes, 2009, 2010).

We selected pictures of scenes to serve as the context. This is ecologically valid, since in real world situations when we are trying to memorize target information, that information is usually experienced within a background context. For example, when you try to remember first meeting someone and try to remember their name, you often try to re-create where you met them and other characteristics of the setting within which you met that person. In the current experiment, the target items were words that were paired with pictures which were the background context. All participants in Experiment 1 completed each of the three encoding conditions in a within-subject design.

In the standard LoP manipulation, a shallow encoding instruction focuses on perceptual or surface features, features which can very easily be determined without requiring deeper thought processes (Craik & Lockhart, 1972). Our encoding instruction asked participants to judge whether a picture was of an outdoor or indoor scene. A standard deep LoP manipulation engages the participant in semantics and meaning of what they are seeing, such as asking whether two words mean the same thing or whether they are pleasant or unpleasant. Our deep encoding manipulation asked the participants to judge whether the picture they saw was pleasant or not, ostensibly engaging them in processing aspects of the picture beyond the surface or perceptual features. The third condition was an associative condition, which asked participants to answer whether the picture of the scene in any way to them matched the word below, in an effort to cause the participants to engage in the meaningful generation of an association between the item and the context.

2.1.1 Method

Participants

Thirty healthy undergraduate students from the University of Waterloo received course credit for participation in the study, and 20 older adults recruited from the Waterloo Research in Aging Pool (WRAP) at the University of Waterloo received a token monetary remuneration for their participation. The WRAP pool is a database of healthy seniors in the Kitchener–Waterloo area recruited by means of newspaper ads, flyers, and local television segments. The mean age of the young adults was 19.63 (*SD* = 1.45, range = 18–22), 18 participants were female. For the older adults the mean age was 73.27 (*SD*=8.05, range = 63-88); with 8 being female. The mean number of years of education was 13.73 (*SD* = 1.53) for the younger adults, and for the older adults it was 13.27 (SD=4.00, range = 8-18), which did not differ. All participants were fluent English speakers, and had normal or corrected-to-normal hearing and vision. The National Adult Reading Test – Revised (NART-R) was also administered to allow an estimate of Full Scale IQ (FSIQ), based on number of errors in pronunciation during vocabulary reading (Blair & Spreen, 1989; Nelson, 1982). The young adults had mean FSIQ estimates of 105.38 (*SD* = 6.37), and the older adults had mean FSIQ estimates of 118.27 (*SD*=4.89), which differed significantly ($t(21) = 6.44$, $p < .001$) and is typical of comparisons between young and older adults (Skinner and Fernandes, 2009).

Materials

A total of 180 medium- to high-frequency words were chosen from CELEX, a lexical database available on CD-ROM (Baayen, Piepenbrock, & Gulikers, 1995), for the three study–test conditions of the study paradigm. All test lists were equated on letter length (M = 6.31) and word frequency (M = 18.27 occurrences per million; Baayen et al., 1995). An additional three sets of five study words and five lure words were used for a brief study-test practice session before each condition, with the same characteristics as the words and pictures in the experimental session.

The pictures of scenes were selected from the International Affective Pictures System (Lang, Bradley & Cuthbert, 2001), a collection of pictures with normative data on valence and arousal ratings, based on a large normative study conducted on college-age students, with each picture having been rated on scales related to valence and arousal, from 1 (very negative or least arousing) to 9 (very positive or most arousing). Of these pictures, 75 which were on average rated relatively neutral (ratings 4.00-5.99) on both arousal and valence measures were selected to be used as context.

In each of three study conditions, the study list was composed of 25 words which were randomly paired with a set of 25 context pictures. A corresponding list of words was compiled for use in the subsequent recognition test consisting of the 25 studied words plus 25 lures (words not presented in the study phase). Thus, across the three study–test conditions, 75 words were paired with 75 context pictures, and 75 words served as lures in the recognition memory test. Three different study–test list combinations of 25 pairs each were created such that each word list was paired with each picture list, or served as a lure across lists, counterbalanced across participants. The order of presentation of the word lists for the three study–test conditions was also counterbalanced.

Procedure

Stimulus presentation and the participants' response recordings were controlled using E-prime v.1.1 software (Psychology Software Tools Inc., Pittsburgh, PA) on an IBM PC. Participants were tested individually and completed the experiment in approximately 1 h. Each participant completed three different study-test conditions, in which the first condition required shallow encoding of context, the second required deep encoding of the context, and the third required binding of target word to context during encoding. Previous work has demonstrated a strong carry-over effect if the 'binding' encoding condition was experienced as the first study-test condition (Skinner & Fernandes, 2009), thus in this experiment we opted to run participants in a fixed order of conditions, with the 'binding' one always last. Thus, there was no counterbalancing of order of condition (but see Experiments 3 and 4 for the between-subjects version of these studies).

In each condition, participants were given a short practice block prior to commencing the experimental condition. For practice in each condition, five study word-picture pairs were shown in random order, using the same timings and procedure as in the experimental trials which will be described below. The only difference between conditions was that encoding instructions differed to reflect the 'shallow', 'deep', and 'binding' encoding manipulation. Subsequently, Old-New test response instructions were given (see below), and 10 recognition trials consisting of the five words studied with pictures and five new words, presented in random order, were presented visually, without any pictures. The test instructions for the Old-New task were as follows: participants were told that they would see some words that were from the study list, and other words that were not. If they believed the word was not from the study list, participants were instructed to respond ‘N’ for New by pressing the ‘3’ key on the numerical keypad of a standard computer keyboard, which was labeled N. If they thought the word was from the study list, they were instructed to respond by pressing the ‘1’ key if the word was ‘old’.

Following each practice, participants completed each study–test cycle in turn. For each of the 3 study conditions, each trial began with a neutral picture presented in the centre of the computer screen for 3500 msec simultaneously with a word displayed in size 28 Arial font centered directly below the picture, after which both the picture and the word disappeared, followed by a 500-ms fixation cross presented centrally on the computer screen. In each of the three study phases, 25 randomly paired picture-word sets were presented. All stimuli were presented in a fully illuminated room on a 17-inch (43.18 cm) computer screen.

In the shallow encoding condition, participants were asked to classify the presented IAPS image as representing an “Indoor” (by pressing 1 on the keyboard) or “Outdoor” (by pressing 2) picture, as this allowed participants to focus on the perceptual characteristics of the image, and conformed to a standard LoP manipulation representing shallow processing, and there approximately half of each presented. In the deep encoding condition, participants were asked to classify whether, in their opinion, they found the IAPS image to be “Pleasant” (by pressing 1 on the keyboard) or “Unpleasant” (by pressing 2), as this allowed for semantic evaluation of the image, and conformed to a standard LoP manipulation representing deep processing. However, each of the pictures presented was rated as neutral on both arousal and valence according to the normative standards defined in the IAPS database. In our associative encoding condition, participants were asked to make a decision regarding whether they found that the IAPS image was “Matched” (by pressing 1) or “Not Matched” (by pressing 2) to the target word with which it was paired in that trial. This encoding instruction was designed to enable formation of links between the context and target information, a process believed to occur spontaneously in younger but not older adults (Naveh-Benjamin, 2000). Participants were also instructed to memorize the target word presented on each trial, for a later memory test. Participants were not provided specific instructions on how to process or encode the target words for the later memory test. Each trial lasted 3500 msec, and participants were asked to make their classification response during this time. After each study phase, participants counted backwards by threes for 15 s to eliminate any recency effects, and then completed the test phase of the experiment.

During the test phase, 50 words (25 studied with context pictures and 25 unstudied lures) were presented in a randomized order. The words were presented in the centre of the screen in the same font and size as at study. Participants were asked to make Old/New recognition responses. Each word remained on the screen for 4000 ms, followed by a fixation cross for 250 ms (see Figure 1). Participants could make their response any time within the 4250 ms of each recognition trial but each participant was told to make their response while the words were on the screen, and that if they did miss responding to a word, they should not worry, and just try to complete the next trial. Participants were given a short break (approximately 10 min) between conditions. The order of presentation of the word lists for the three conditions was counterbalanced across participants.

2.1.2. Results

Data from one young adult and from two older adults were excluded from all analyses as their memory performance fell more than 3 standard deviations from the overall mean of their respective groups.

Hit Rate

Hit Rate was calculated as the total number of Hits divided by the total possible number of correct hits (Hits/25) per condition. To investigate how performance between younger and older adults differed, a repeated measures ANOVA was conducted with age group entered as a between-subject factor, and encoding condition as a within-subject factor. There was a main effect of encoding condition ($F(2, 88) = 27.69$, $MSE = .01$, $p < .001$), but no effect of age group ($F(1,44) = 0.53$, $MSE = .02$, $p = .47$) and no condition X age interaction ($F(2,88) = 1.33$, $MSE = .01$, $p = .27$)(see Table 1 for means). Simple effects indicated that the associative condition led to a greater Hit Rate than both the shallow ($F(1,44) = 27.96$, $MSE = .03$, $p < .001$) and the deep ($F(1,44) = 53.04$, $MSE = .03$, $p < .001$) encoding conditions, but that there was no difference in Hit Rate between the deep and shallow encoding conditions ($F(1,44) = 1.23$, $MSE = .02$, $p = .27$).

False Alarm Rates

False Alarm Rate was calculated as the total number of incorrect ‘yes’ responses made per condition divided by the number of study trials per condition (25). A repeated measures ANOVA was conducted with Condition as a within-subjects factor and Age group as a between-subject factor. There was no effect of Condition ($F(2,88) = 1.11$, $MSE = .01$, $p = .34$), although the main effect of Age ($F(1,44) = 4.57$, $MSE =.01$, $p = .04$) was significant, with older adults making more false alarms overall than young adults. The Condition X Age interaction was non-significant ($F(2,88) = 0.95$, $MSE = .01$, $p = .39$; see Table 1 for False Alarm means by group).

Recognition Accuracy

Overall recognition accuracy was calculated as (# of hits - # of false alarms)/25. To assess the effect of the encoding conditions on recognition accuracy, we conducted a repeated measures ANOVA with Condition as a within-subject factor and Age Group as the between-subjects factor. There was a main effect of Condition ($F(2,88) = 25.45$, $MSE = .02$, $p < .001$), with the associative encoding condition leading to significantly higher accuracy than both the shallow ($F(1,44) = 28.26$, $MSE = .05$, $p < .001$) and the deep ($F(1,44) = 50.60$, $MSE = .05$, $p < .001$) encoding conditions. However, there was no significant difference between the shallow encoding condition ($F(1,44) = .02$, $MSE = .03$, $p = .88$) and the deep encoding condition. There was also a significant effect of Age ($F(1,44) = 5.69$, $MSE = .01$, $p < .001$),with poorer accuracy overall in older than in younger adults, and there was a significant Condition X Age interaction ($F(2,88) = 3.05$, $MSE = .02$, $p = .05$).

A separate repeated measure ANOVA was conducted on the accuracy measures for each age group separately, to further investigate the Condition X Age interaction. For the younger adults, there was a significant effect of condition ($F(2,56) = 25.53$, $MSE = .02$, $p < .01$), with contrasts indicating that the associative condition performance was significantly better than that in both the shallow ($F(1,28) = 20.16$, $MSE = .03$, $p < .01$) and the deep ($F(1,28) = 42.11$, $MSE = .04$, $p < .01$) encoding conditions, as well as a significant difference between the deep and shallow encoding conditions ($F(1,28) = 7.19$, $MSE = .02$, $p = .01$), with better performance in the shallow condition.

For the older adults, there was a significant effect of condition ($F(2,32) = 7.83$, $MSE = .02$, $p < .01$), with simple effects indicating significantly higher accuracy following the associative condition compared to the deep ($F(1,16) = 22.17$, $MSE = .07$, $p < .01$) and the shallow ($F(1,16) =$

9.58, *MSE* = .01, $p < .01$) encoding conditions, though there was no significant difference between the shallow and deep encoding conditions (F(1,16) = 1.46, *MSE* = .05, p = .25).

Table 1: **Experiment 1.** Recognition Task Performance by Condition with Neutral Context Pictures. Standard Deviations are shown in parentheses.

Condition	Shallow		Deep		Associative	
Measure	Young	Old	Young	Old	Young	Old
Hit Rate	.65 (.16)	.57 (.19)	.61 (.17	.56 (.22)	.78 (.18)	.68 (.21)
False Alarm Rate	.07 (.10)	.16 (.24)	.10 (.17)	.14 (.14)	.06 (.08)	.11 (.11)
Accuracy	.58 (.16)	.41 (.20)	.50 (.15)	.45 (.23)	.72 (.19)	.58 (.22)

Encoding Classification Task Median RT.

A potential concern was that both the shallow and the deep encoding conditions seemed more like dual tasks, namely, memorizing the word *and* answering the encoding question about the pictures, whereas in the associative memory condition may have seemed like they are doing only one task, namely, memorizing the word *by* answering the encoding question. If this were the case, we would expect that there would be a relationship between accuracy performance and the amount of time taken to answer the context encoding question, since if the associative condition was being viewed as a single task, it would be expected that the time to answer the encoding question would be much shorter than in the first two encoding conditions, if they were treated as dual tasks.

To examine this possibility, a bivariate correlation was conducted between accuracy performance in each condition and the median response time (RT) taken to answer the encoding question for each age group. There was no reliable relation of encoding RT (see Table 2) with performance in the shallow (*r*(27) = .30, *p* = .12), the deep (*r*(27) = .14, *p* = .47), or the associative (*r*(27) = .25, *p* = .19) encoding condition with the young adults. For the older adults, there also was no reliable relationship between encoding RT and accuracy in the shallow (*r*(15) = .10, *p* = .71), deep (*r*(15) = .26, *p* = .31), or associative (*r*(15) = .06, *p* = .82) encoding condition.

Table 2: **Experiment 1**. Average Median Response Time to Make Encoding Responses with Neutral Context Pictures. Standard deviations are noted in parentheses

	Age Group	
Encoding Condition	Young	Old
Shallow	1486.40 (312.16)	1696.89 (316.06)
Deep	1617.17 (337.27)	2189.42 (330.63)
Associative	1771.27 (233.26)	2315.07 (290.46)

2.1.3. Discussion

To summarize, there was a significant impact of Condition on Hit Rate performance, but no difference by Age Group and no interaction between Condition and Age Group. The associative encoding condition led to more correct hits (correctly recognized study words) than either other encoding condition, and the two LoP encoding conditions did no differ in the amount of Hits that they helped generate (see Figure 1). This indicates that the associative condition leads to both more hits *and* more of them are correct than in the LoP conditions. It also indicates that if there are any differences between the accuracy performances in the LoP conditions, it would be due to False Alarm Rates, because there are no differences in these conditions as indicated by the Hit Rate data.

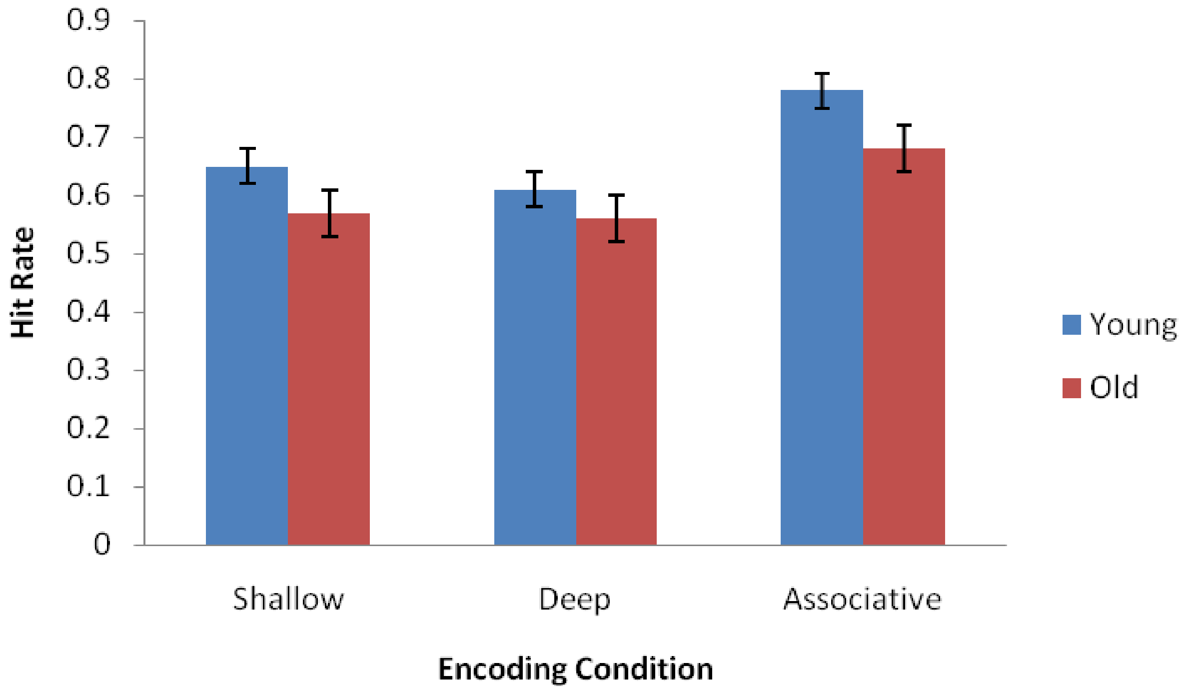

Figure 1: Experiment 1. Age Comparison of Hit Rates by Condition with Neutral Context Pictures in Within-Subject Design.

However, when we examined the False Alarm data, interestingly, there was no main effect of Condition indicating that none of the encoding conditions in this experiment led to greater or fewer false alarms. There was a main effect of Age, demonstrating that overall, older adults made more errors than younger adults, but this is in line with other studies of memory in older adults.

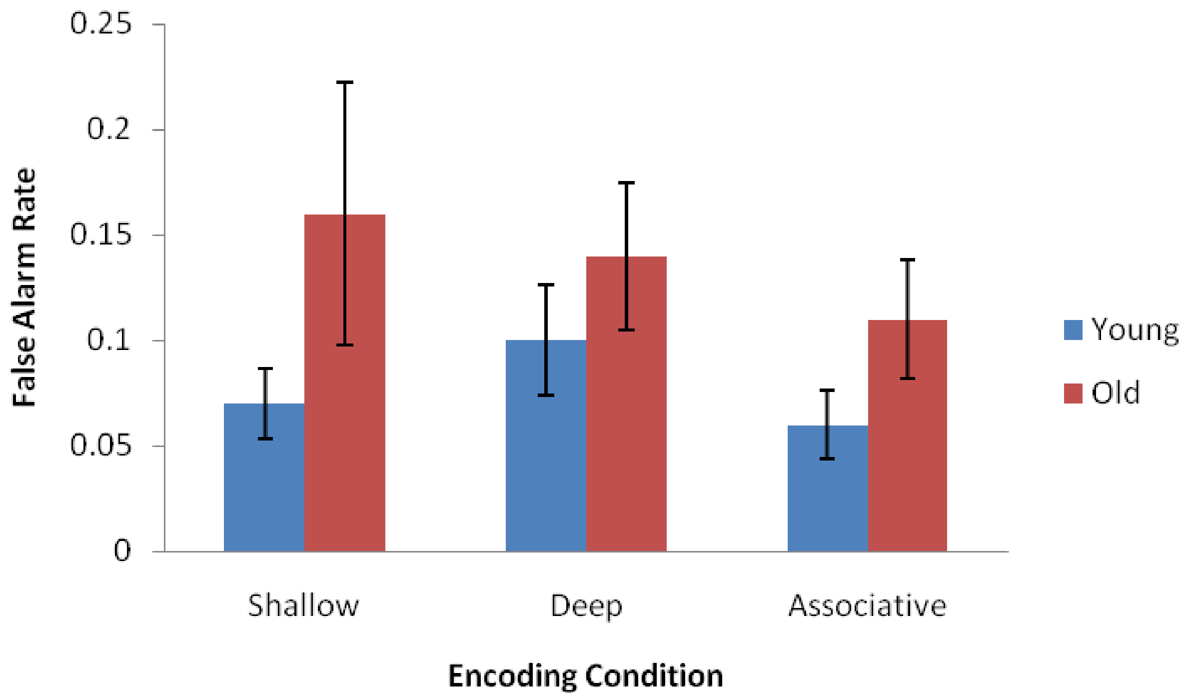

Figure 2: Experiment 1. Age Comparison of False Alarm Rates by Condition with Neutral Context Pictures in Within-Subject Design.

Now, moving on to discuss the aggregate measure, accuracy (Hit Rate - False Alarm Rate) there was a significant impact of the encoding manipulations on the context information on later item memory accuracy, and there was an age X encoding condition interaction. In younger adults, the deep encoding condition led to significantly poorer memory accuracy than the shallow condition (see Figure 3), although the associative encoding condition led to significantly better memory accuracy than both the shallow and the deep encoding conditions. Since there was a reduction in performance in the younger adults from the shallow condition to the deep condition, it led us to question, in Experiment 2, why we did not get the expected better performance following a deep LoP. This problem was found only in the younger adults, as the older adults still showed a slight, but not significant, LoP benefit from deep compared to shallow encoding of the context pictures.

For the older adults, there was no significant difference in the accuracy performance between the deep and shallow encoding condition, and the associative encoding condition led to significantly better memory performance than both the deep and the shallow encoding condition.

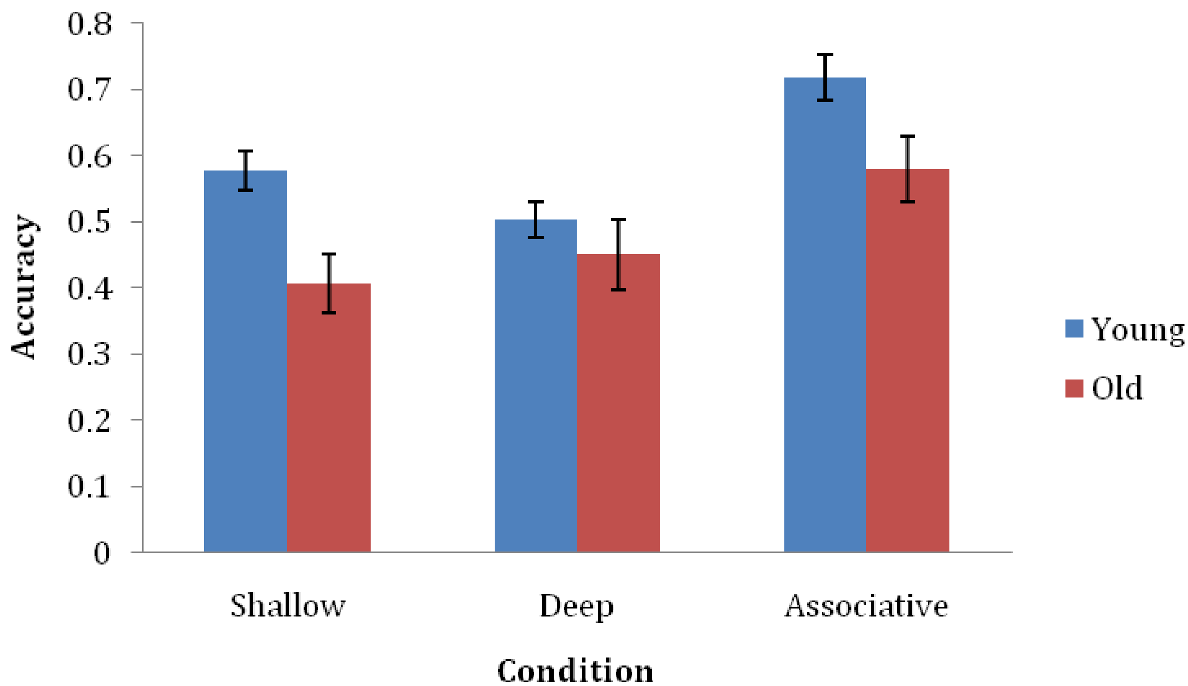

Figure 3: Experiment 1. Age Comparison of Accuracy Performance by Condition With Neutral Context Pictures in Within-Subject Design.

In conclusion, with both young and older adults, the associative encoding condition led to significantly improved memory performance compared to the two LoP encoding conditions. This is an important finding as it demonstrates that although there may be persistent deficits with older adults' ability to automatically form associations and utilize them at retrieval, in a condition where they are specifically instructed to engage in this kind of encoding they show a robust benefit, even if the associative instruction is on context information peripheral to the targets which are to be recognized. This demonstrates that context can not only be useful if it is reinstated, it can in fact be useful if it is intentionally encoded as a part of the memory, even if it is not reinstated at retrieval.

The expected LoP effect was not found to be significant either among the young or the older adults. Unexpectedly, the younger adults actually showed the opposite effect, with the deep condition leading to worse performance than the shallow condition (see Figure 3). This indicated a potential flaw in the design of the deep encoding condition, either in the selection of the encoding question or in its application to the materials used in this memory paradigm. Another possible explanation is that perhaps they were too deeply engrossed in processing the context that memory for the target words was impaired.

Since the correlations comparing the response times to later memory accuracy indicated that there was no relation between the amount of time taken to make the encoding response and later memory accuracy, there may be other reasons why the deep LoP encoding condition did not significantly enhance memory performance compared to the shallow encoding condition with the young adults. The most likely possibility is that there was not enough variance in the emotional valence in the neutral context pictures used in Experiment 1 to allow the deep encoding manipulation, which required judgments of pleasantness, to be meaningful. In everyday life when we are asked to make judgments of pleasantness there is typically a wide range going from one extreme to the other, and perhaps it is this ability to judge with respect to the wide range and to the opposite extremes which allows a pleasantness judgment to be so useful as a deep encoding manipulation. As such, our selection of neutral stimuli may have caused the deep LoP encoding question regarding the pleasantness of the pictures to be ineffectual in improving memory. In order to address this potential problem, we decided to run a second experiment with a new set of context pictures, which were emotional rather than neutral.

2.2 Experiment 2

Brief Introduction

Experiment 1 indicated that encoding manipulations of unrelated context information, presented concurrently during encoding, can influence subsequent recognition memory for target information. Older adults showed a modest increase of a deep compared to a shallow encoding manipulation on later memory performance, although it wasn't significant, and binding instructions helped memory even more than a deep encoding of the context. Unexpectedly, with the younger adults, the shallow encoding condition actually led to better memory than the deep one. It is unclear whether LoP of context information during encoding follows the expected LoP pattern noted when this is applied to target information, or whether there is a confound in our design which masks this effect.

Because the deep encoding instruction asked whether the picture was pleasant or not, it is possible that our use of specifically selected neutrally valenced pictures as stimuli would not allow this instruction to be meaningful. There was little in the stimuli to evoke a pleasant or unpleasant feeling concurrent with encoding of the context and thereby evoke an emotional response leading to a boost in memory due to emotional processing.

Work by McGaugh and Cahill (1995) has demonstrated that memory performance can be improved if emotional stimuli compared to neutral stimuli are used. Furthermore, if we reflect on what makes an emotional judgment useful as a deep LoP manipulation, in everyday life when we are asked to make judgments of pleasantness there is typically a wide range going from one extreme to the other. Perhaps it is this ability to judge in accordance with the wide range and to the opposite extremes which allows a pleasantness judgment to be so useful as a deep encoding manipulation.

Consequently, we decided to run the same experimental paradigm again, except this time we used context pictures from the positive and negative ends of the valance rating, excluding the most neutral pictures, while still maintaining neutrality of arousal levels. We hypothesized that this change would lead to increased memory performance overall, and specifically that this change would allow more meaningful answers to the deep encoding manipulation regarding pleasantness of image allowing us to demonstrate a standard LoP effect, even though the manipulation is on the context and not the item being tested as is traditionally done.

We hypothesize that, since the deep encoding manipulation would now be more meaningful, both younger and older participants will show a traditional LoP effect of deep encoding leading to better memory than the shallow encoding condition, even though the encoding manipulation is directed toward the contexts while concurrently memorizing the target item present simultaneously with the context picture. We also predict, given the evidence by McGaugh and Cahill (1995) suggesting that emotional information is better remembered than neutral information, that the use of emotional pictures as context would lead to better memory than the use of neutral pictures. In addition, we also wanted to test the general reliability of our finding in Experiment 1 that the associative condition leads to the best memory in both age groups.

2.2.1 Methods

Participants

A set of thirty naïve, healthy undergraduate students from the University of Waterloo received course credit for participation in the study. The mean age was 20.13 (*SD* = 1.36, range = 18–22; 20 female), and the mean number of years of education was 14.70 (*SD* = 1.27, range = 13-17). Twenty-eight naïve older adults were also recruited from WRAP, and received a token monetary remuneration for their participation. Their mean age was 74.35 (*SD* = 8.53, range = 61-89; 21 female), and the mean number of years of education was 15.14 (*SD* = 3.95, range = 8-22), which did not differ significantly from the young adults. All participants were fluent English speakers, and had normal or corrected-to-normal hearing and vision. The National Adult Reading Test – Revised (NART-R) was also administered to allow an estimate of Full Scale IQ (FSIQ), based on number of errors in pronunciation during vocabulary reading (Blair & Spreen, 1989; Nelson, 1982). The young participants had mean FSIQ estimates of 107.83 (*SD* = 5.70) and the older adults had a mean FSIQ of 117.13 (*SD* = 7.79), which differed significantly ($t(1,29) = 2.75$, $p < .05$).

Materials

A total of 192 medium- to high-frequency words were chosen from CELEX, a lexical database available on CD-ROM (Baayen et al. 1995) for the three study–test conditions of the study paradigm. These were the same as those used in Experiment 1 with the addition of 12 more words selected using the same criteria as before since in Experiment 2 there was one more trial in each of the practice and study encoding and retrieval sessions in order to make the ratio of positive and negative sessions even.

The pictures of scenes were selected from the IAPS (Lang et al., 2001). Of these pictures, 48 were rated negative (1.00-4.2 on a scale of 1-9) and 48 were rated positive (5.8-9.00) in valence, according to the normative study of IAPS images (Lang et al., 2001) but which were all still rated neutral on arousal (4.00-5.99 rating in arousal on a scale of 1-9).

In each of the three study conditions, the study list was composed of 26 words which were randomly paired with a set of 26 context pictures (13 positive pictures, 13 negative pictures). A corresponding list of words was compiled for use in the subsequent recognition test (in which the pictures were not shown), consisting of the 26 studied words plus 26 lures (words not presented in the study phase). Thus, across the three study–test cycles, 78 words were paired with the 78 emotionally valenced context pictures and 78 words served as lures in the recognition test. Three different study–test list combinations were created such that each word list was paired with each picture list, or served as a lure across lists, counterbalanced across participants.

The order of presentation of the word lists for the three study–test cycles was counterbalanced. An additional three sets of six study words-pictures lists and six lure words were used for a brief practice session before each condition, with the same characteristics as the words and pictures in the experimental session.

Procedure

The procedure for Experiment 2 was the same as Experiment 1 (see above), as the only difference between the experiments was that there were different sets of pictures and there were 26 trials per condition rather than 25, in order to allow for an equal ratio of positive to negative valenced context trials.

2.2.2 Results

Data from two of the younger adults were excluded as their accuracy fell more than 3 standards deviations from the mean.

Hit Rates

Hit Rates were calculated as the total number of correctly recognized old words out of 26 trials (per condition) (Hits /26). A repeated measures ANOVA was conducted with Condition as a within-subject factor and Age group entered as the between-subject factor. There was a main effect of Condition ($F(2,108) = 15.09$, $MSE = .01$, p < .001), with the associative condition having higher Hit Rates than both the deep ($F(1,54) = 20.96$, $MSE = .01$, $p < .001$) and the shallow ($F(1,54) = 23.15$, $MSE = .01$, $p < .001$) conditions, but again there was no difference between the deep and the shallow condition ($F(1,54) = 0.12$, $MSE = .02$, $p = .73$). There was a main effect of Age ($F(1, 54) = 5.15$, $MSE = .02$, $p = .02$), with older adults performing poorer than younger adults overall (see Table 2). There was also a significant Condition X Age interaction ($F(2,108) = 3.89$, $MSE = .01$, $p = .02$).

To investigate the interaction further, simple effects analyses were conducted on each age group separately. For the younger adults, the shallow condition did not differ significantly from the deep ($F(1, 27) = 2.25$, $MSE = .01$, $p = .14$), but it did differ from the associative condition ($F(1, 27) = 14.75$, $MSE = .01$, $p < .001$), as did the deep condition ($F(1, 27) = 23.94$, $MSE = .03$, $p < .001$). For the older adults, however, the deep condition did not differ from the associative condition ($F(1, 27) = 2.56$, $MSE = .01$, $p = .12$), or from the shallow condition ($F(1, 27) = 2.28$, *MSE* = .03, *p* = .14), but the shallow condition was lower than the associative condition (*F*(1, 27) = 7.27, *MSE* = .03, *p* = .01).

False Alarm Rates

False Alarms Rates were calculated as the number of new words incorrectly 'recognized' as old words, (incorrect hits) out of 26 new words (False Alarms/26). False Alarm Rate data were analyzed using a repeated measures ANOVA with Condition as a within-subject factor and Age as a between-subject factor. There was a main effect of Condition ($F(2,108) = 4.57$, $MSE = .01$, $p = .01$), with the associative condition having a significantly lower False Alarm Rate than both the shallow ($F(1,54) = 7.09$, $MSE = .01$, $p = .01$) and the deep condition ($F(1,54) = 6.81$, $MSE = .01$, $p = .01$), but there was no difference between the shallow and deep conditions ($F(1,54) = 0.48$, $MSE = .01$, $p = .49$). There was a main effect of Age ($F(2,108) = 7.33$, $MSE = .02$, $p < .01$), with older adults having higher False Alarms Rates than young adults, but there was no Condition X Age interaction ($F(2,108) = 2.10$, $MSE = .01$, $p = .13$).

Accuracy Performance

Accuracy was calculated as the Hit Rate minus the False Alarm Rate, since there were equivalent old and new words presented in the retrieval task (Hits-False Alarms/26). A repeated measures ANOVA was conducted on the Accuracy performance across the three encoding conditions, with Age Group entered as a between-subject factors. There was a main effect of Condition ($F(2,108) = 24.02$, $MSE = .02$, p < .001), with the associative encoding condition significantly better relative to the shallow ($F(1, 54) = 33.73$, $MSE = .04$, $p < .001$) and the deep ($F(1, 54) = 30.87$, $MSE = .04$, $p < .001$) encoding conditions. However, there was no significant difference between the shallow and the deep encoding conditions. There was a main effect of

Age Group ($F(2,108) = 35.74$, $MSE = .01$, $p < .001$), with higher accuracy in younger than older adults overall, but no Age X Condition interaction ($F(2,108) = 2.29$, $MSE = .01$, $p = .11$).

Table 3: **Experiment 2.** Recognition Task Performance by Condition with Emotional Context Pictures. Standard deviations in parentheses.

Condition	Shallow		Deep		Associative	
Measure	Young	Old	Young	Old	Young	Old
Hit Rate	.69 (.15)	.59 (.19)	.66 (.16)	.64 (.21)	.81 (.09)	.68 (.21)
False Alarm Rate	.16 (.19)	.20 (.20)	.15 (.18)	.25 (.25)	.09 (.10)	.18 (.14)
Accuracy	.51 (.25)	.39 (.15)	.51 (.23)	.39 (.18)	.72 (.14)	.49 (.17)

Comparison of Encoding RTs and Accuracy

We again conducted bivariate correlations within each of the age groups to determine whether there was any relation between the amount of time it took participants to answer the classification question during encoding and their later recognition memory performance. For the younger adults, there was no correlation between accuracy in either the shallow $r(28) = .29$, $p > .05$) or the associative ($r(28) = -.15$, $p > .05$) encoding conditions. There was a significant positive correlation between processing time and accuracy and median classification response time ($r(28) = .47$, $p < .05$) in associative condition. For the older adults, there was no significant correlation between accuracy and median classification response times in the shallow ($r(28) = .06$, $p > .05$), deep ($r(28) = -.25$, $p > .05$), or the associative ($r(28) = .02$, $p > .05$) encoding conditions.

2.2.3 Discussion

When examining the Hit Rate data, there was again a main effect of condition, with the associative condition leading to more Hits than either the deep or the shallow condition, and there was no difference in Hit Rate between the deep and shallow condition (see Figure 4). This means that the addition of the emotional context pictures vs. the neutral context pictures used in Experiment 1 did not lead to a difference in correct Hits between the shallow and the deep encoding conditions. The main finding of Experiment 1 was replicated with the associative condition again leading to the most correct Hits. There was again a main effect of Age, with the older adults having fewer Hits overall than younger adults, and there was significant Condition X Age interaction.

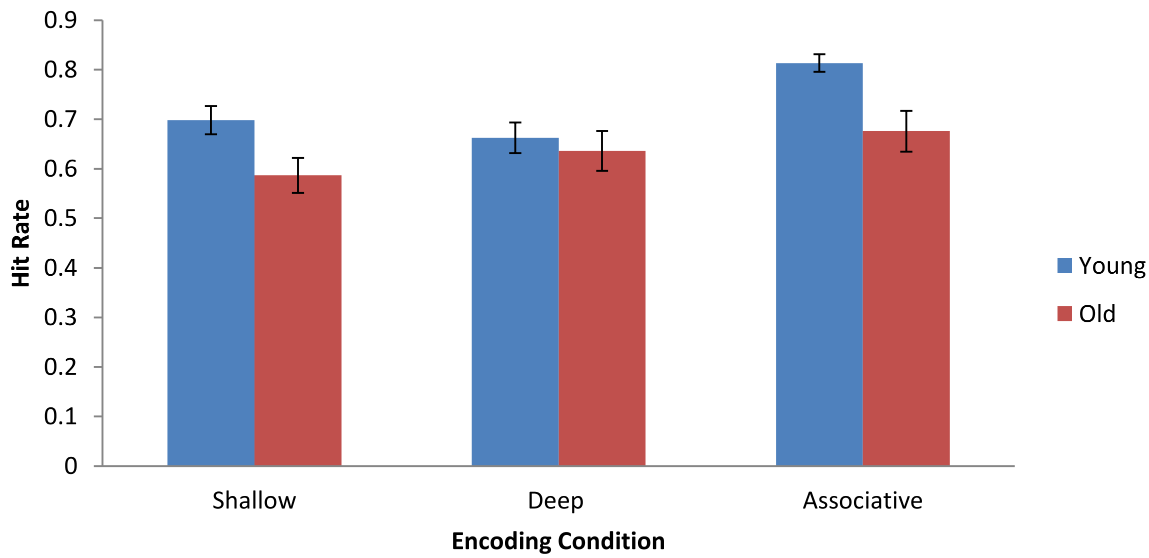

Figure 4: **Experiment 2.** Age Comparison of Hit Rates by Condition with Emotional Context Pictures in Within Subjects Design. Error bars represent the SE of each condition.

The interaction revealed that there was so little change in Hit Rates from shallow to deep conditions to associative with the older adults that the deep condition did not differ significantly from either the shallow or the associative condition, although the shallow and the deep did differ significantly.

The False Alarm data did not reveal anything startling either, as there was again a main effect of condition, with the associative condition leading to fewer False Alarms than either the deep or the shallow conditions, but there was again no difference in False Alarms between the deep and the shallow conditions (see Figure 5). There was a main effect of age again, with older adults again making more errors than younger adults, but there was no interaction between Age and Condition. This again highlights a two-fold problem with the older adult's poorer memory performance, that being that they generate fewer correct Hits when completing the task AND that they erroneously identify lure words targets more often.

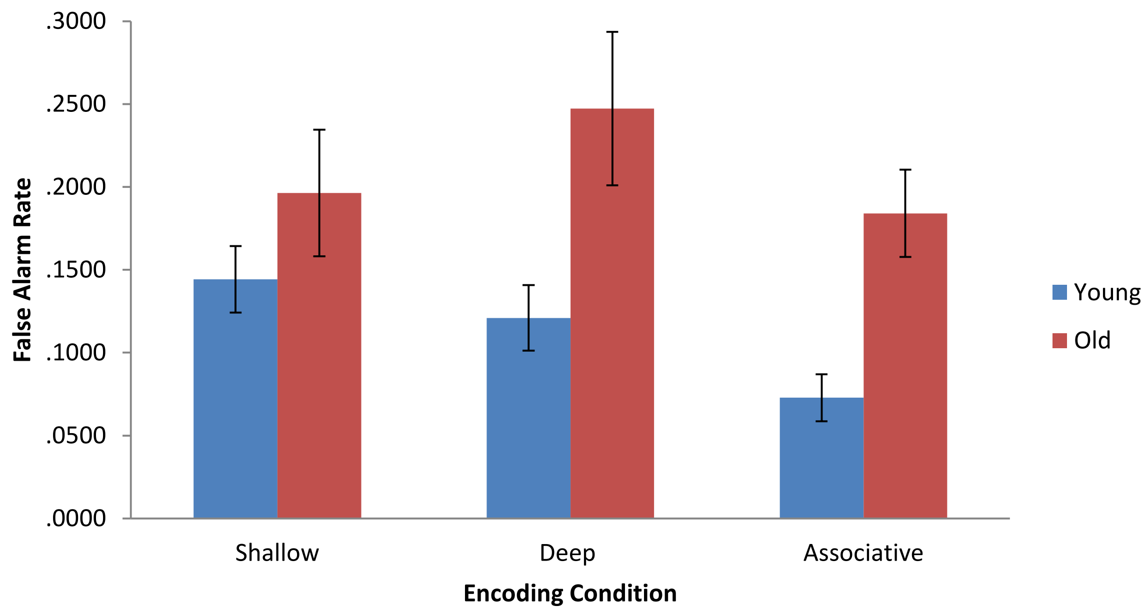

Figure 5: **Experiment 2.** Age Comparison of False Alarm Rates by Condition with Emotional Context Pictures in Within-Subject Design.

It comes as no surprise, then, when we examine the accuracy data which is an aggregate measure of both Hits and False Alarms that the same pattern emerges, with the associative condition consistently proving to lead to the best memory performance in both younger and older adults. There was still no difference between the deep and the shallow LoP encoding conditions (see Figure 6), even though in this version of the experiment emotional context scenes were utilized compared to the neutral ones used in Experiment 1. One thing to note, however, is that whereas in Experiment 1 the deep encoding condition actually led to significantly poorer accuracy than the shallow condition with the younger adults, in this version with emotional context scenes there is no longer any difference between the two conditions.

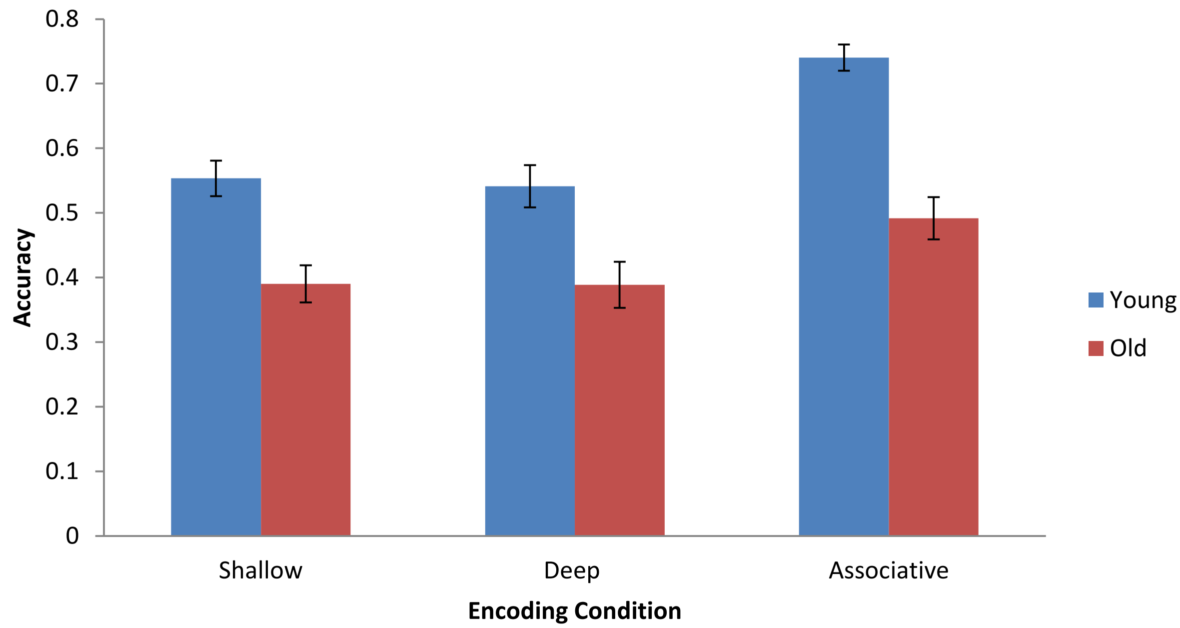

Figure 6: Experiment 2. Age Comparison of Accuracy Performance by Condition with Emotional Context Pictures in Within Subjects Design. Error bars represent SE of each age group in each condition.

With regard to the classification response times, there was again no consistent pattern that would indicate that the amount of time that participants took to answer the classification questions differed in a systematic way that impacted their memory performance. In fact, the only significant correlation found, with the young adults in the deep encoding condition, found that the longer it took the participants to answer the encoding question about the image, the better their memory performance was for the word.

Limitations

Since this paradigm used a within-subject design, with each participant completing each of the three conditions in sequence, another possible explanation for the lack of a LoP effect is that there were interference effects from the previously used encoding strategy, which was erroneously applied in later encoding conditions. Furthermore, the design of Experiments 1 and 2, being within-subject, may have led to fatigue, thereby obscuring any benefit from a deep LoP of the context. It is also possible that by the time participants performed the third condition, they may have learned the paradigm quite well, and this may have led them to perform the best on the third condition demonstrating an effect of practice, rather than an actual benefit of associative encoding.

The only way to determine whether our pattern of effect was due to some of the possible designs issues with the within-subject design was to re-run both experiments, but this time in a between-groups design, with each participant completing only one of the encoding manipulations, rather than all three in sequence. This was done, in part, and data are presented in the next chapter of this thesis, following a discussion of the results thus far.

2.3 Experiments 1 and 2 General Discussion

The main finding in both of these experiments was that an associative encoding condition related to the context led to better memory performance in both younger and older adults. A LoP manipulation of encoding of visual images, presented concurrently with target words, as context did not differentially boost memory for target words. Notably the associative encoding condition led to higher memory than either of the LoP conditions. One of the aspects of the series of studies conducted by Naveh-Benjamin (2000) was that, when he instructed participants to memorize either single units of information or pairs, older adults were significantly impaired in remembering the pairs compared to the single units, leading him to postulate that older adults have an associative deficit, a deficit in the ability to form meaningful associations between units of information within a memory and to efficiently utilize those associations at retrieval.

However, what we have demonstrated with these experiments is that if older adults are given a type of association to engage in forming between units, rather than simply instructed to memorize pairs of item and context, they can form the associations and use them relatively efficiently at retrieval, as indicated by the robust improvement in memory performance demonstrated by our two groups of seniors in both experiments. This has implications in that although they may not be able to make associations if left to their own devices, if given the correct tools or types of associations to use in a given instance, perhaps some of the memory deficits of older people can be alleviated. Future studies can investigate ways to incorporate these findings into everyday memory taxing situations to mine the rehabilitative potential of this manipulation.

Although LoP effects have been robustly shown for numerous types of stimuli and across age groups (Craik & Lockhart, 1972; Eysenck, 1974) as discussed in the introduction, the manipulations have always been conducted on the item that is later tested for memory performance. In our two experiments, we investigated whether the LoP effect improves memory for more than just the item engaged by the encoding instruction, if the LoP benefit is very focused or more diffuse in its improvements to memory. We have discussed how memory is never really a single unit or item, but rather a holistic event, and in relation to this we explored whether a LoP manipulation impacts only the memory for an item in an event, or the whole event itself. By focusing the encoding instruction on the context, rather than the item, we hoped to demonstrate that a deep LoP condition actually improves the whole memory (holistically).

What we found in Experiment 1, for the young participants was quite the opposite with the shallow condition being better than the deep, although the finding is likely attributable to a confound within the design, which we attempted to remediate in Experiment 2. Here we were again unsuccessful at demonstrating a holistic increase in memory with a deep condition compared to a shallow condition, but the addition of emotional context stimuli did partially remediate the potential confound in Experiment 1 in that the deep condition no longer led to poorer memory performance than the shallow condition. An important aspect to note is that, whatever the confounds are, they seem to affect the younger adults more than the older adults, as the older adults are at least trending in the expected direction with regards to the shallow and deep encoding conditions. As such, the current set of data from Experiment 1 and 2 does not contribute very much of applicability to the levels of processing research, although more will become clear after further potential confounds within the experiment design are addressed (see Chapter 3).

Limitations

Since this paradigm was a within-subject design, with each participant completing each of the three conditions in sequence (given that previous work in our lab has demonstrated that if the order of conditions is counterbalanced, there are strong carryover effects of the associative condition on subsequent conditions in a within subject design (Skinner & Fernandes, 2009)), another possible explanation for the lack of an LoP effect is the effect of interference. That is, participants completed the second condition after completing the first condition which was very similar with only a slight change in instructions. Since there was very little time to physically differentiate the two conditions, and the types of stimuli used were very similar, participants may have still have had item-context pairs from the first condition fresh in their mind and this may have interfered with the learning of even more item context pairs in the second condition.

Given that they performed so well on the third condition, however, it is possible that they realized that the previously learned lists will not be tested again, resulting in less interference, or that the benefits of the associative condition were so robust that they were able to overcome these interference effects. By the time they got to the third condition, they may have learned the paradigm quite well, and this may have led them to perform the best on the third condition, namely a demonstration of practice effects, rather than an actual benefit of associative encoding, or their performance was still impaired, due to interference of multiple similar previously learned lists, and their performance in the associative condition could have been even better.

Associated with these possible effects are the possible detrimental effects of fatigue, since completing all three conditions took over an hour for many participants, and the task is not very exciting or stimulating. The only way to determine this would be to extend this paradigm to incorporate a between-subject design with each participant only completing one type of encoding condition, rather than all three in sequence, which would address the limitations of possible order effects, fatigue effects, and/or practice effects.

The shallow data already collected would not likely have been impacted by the above mentioned limitations, as it was always performed first; only recognition for target words in the deep and associative encoding conditions would have been affected by studying and testing several lists in succession.

Chapter 3

Between-Subject Examination of the Effect of Encoding Context on Item Memory: Extension to Experiment 1 and 2

3.1 Experiment 3 (Extension to Experiment 1)

One of the main limitations of Experiments 1 and 2 was that since each participant did each type of encoding condition, each in the same order, there is the possibility that fatigue is impacting the pattern of results, especially in the last two encoding conditions, since there the tasks were very similar and participants may have begun to feel inundated with information the further into the task they progressed. As such, it may be that fatigue is lessening the benefit of deeply encoding the context information, and that instructions to link context to target words potentially have an even greater effect on memory than our experimental design revealed in Experiments 1 and 2.

To explore this hypothesis, we re-ran Experiments 1 and 2, but in a between-subjects design. The data collection for this part of the Masters thesis are incomplete, as a between-subjects design required an extra 128 participants to be run in the study. Nonetheless we report the data collected thus far as they impact the general conclusions of this Masters thesis. Since the young adults are easy to obtain, each condition in Experiment 1 and 2 was run independently with a unique group of young adults (6X18=108 new participants). However, when we reassessed the number of seniors available who matched our criteria for inclusion in our study, there were relatively few older adults available to participate from our participant pool (WRAP). As such the older adults each ran only one type of encoding condition (i.e. deep or associative), but they completed both the Experiment 1 and Experiment 2 versions of these conditions. Since in Experiment 1 and 2, when the participants completed the shallow condition they were still naive, it is not expected that these results would differ from another group of seniors who only completed the shallow condition in a between subjects design, therefore it was decided to reuse the shallow encoding condition data collected from the seniors in Experiment 1 and 2 for comparison against the newly collected between-subject data collected on the deep and associative encoding condition. Specifically, we considered data from the shallow condition, which was always the first one completed in Experiments 1 (N = 20) and 2 (N = 20). We compared these to new data collected in seniors who completed either the deep (N = 14) or binding condition (N = 10). These additional seniors completed either the deep or the associative conditions of Experiments 1 and 2. While we realize this is a less than optimal sample to examine between-subjects effects, we nonetheless analyzed these preliminary data to determine whether a between-subjects design radically changed the pattern of results.

3.1.1 Method

Participants

A set of 54 healthy undergraduate (34 female) students from the University of Waterloo received course credit for participation in the study, with three groups of 18 students each completing one of the three different study conditions. In addition, older adults from the WRAP participant pool also participated, receiving monetary remuneration for their participation, with 14 completing the deep encoding condition and 10 completing the associative condition. The mean age of the younger adults was 18.78 (*SD* = 1.21, range = 17-21), and the mean age was 73.98 (*SD* = 7.64, range = 61-89) for the older adults. Mean number of years of education was 13.74 (*SD* =1.29, range = 13-18) for the younger adults and the older adults had a mean years of education of 15.23 (*SD* = 3.61, range = 8-22), which differed significantly ($t(58) = 12.48$, $p < .01$).

For comparison, data from performance in the shallow condition from the first 20 seniors from Experiment 1 were included here. In both the current experiment, and the extension to Experiment 2 described below, the seniors in the deep and associative conditions completed that condition in both the extension to Experiment 1 (with neutral images) and the extension to Experiment 2 (with emotional images), with the order of experiment counterbalanced across participants. To try to ensure that the two sessions remained as distinct as possible, these older adults were given a 10-15 minutes break between experiments, and given a tour of the main lab area in between the two test sessions.

All participants were fluent English speakers, and had normal or corrected-to-normal hearing and vision. The National Adult Reading Test – Revised (NART-R) was also administered to allow an estimate of Full Scale IQ (FSIQ), based on number of errors in pronunciation during vocabulary reading (Blair & Spreen, 1989; Nelson, 1982). The young participants had mean FSIQ estimates of 103.81 (*SD* = 7.62), and the older adults had a mean FSIQ of 116.58 (*SD* = 7.49), which differed significantly ($t(58) = 4.48$, $p < .001$).

Materials

All of the materials and stimuli used were identical to the materials used in Experiment 1, described previously.

Procedure

The procedure for each of the conditions was identical to what was done in Experiment 1. The only difference in this extension study was that, for the young adults, there were three randomly assigned groups of 18 participants, and each group completed only one of the encoding conditions. For the older adults, data for the shallow encoding condition were taken from the shallow condition from Experiment 1, since this condition was always completed first (thus no new seniors were run in this condition). In addition, 14 seniors completed only the deep encoding condition and 10 seniors completed only the associative encoding condition.

3.1.2 Results

A multivariate ANOVA was conducted, with Hit Rate, False Alarm Rate, and Recognition Accuracy entered as the dependent variables, and with Age and Condition as between-subject factors.

Hit Rate

There was a main effect of Condition on Hit Rate ($F(2, 84) = 5.47$, $MSE = .02$, $p < .01$), with the associative encoding condition having a significantly higher Hit Rate than the shallow condition ($t(57) = 3.05$, $p = .004$) and a higher Hit Rate than the deep condition ($t(53) = 2.46$, $p = .02$). There was no difference between the deep and the shallow condition ($t(64) = 1.24$, $p = .22$) (see Table 3). There was no main effect of Age on Hit Rate ($F(1, 84) = 2.35$, $MSE = .02$, $p = .13$), and no Condition X Age interaction ($F(1, 84) = 1.19$, $MSE = .02$, $p = .31$).

False Alarm Rate

There was no main effect of Condition ($F(2, 84) = 1.64$, $MSE = .02$, $p = .20$), or Age ($F(1, 84) = 2.71$, $MSE = .02$, $p = .10$) on False Alarm Rate, nor was there a Condition X Age interaction of False Alarm Rates ($F(2, 84) = 0.35$, $MSE = .02$, p = .71).

Accuracy

When we examined the combination of Hit Rate and False Alarm Rate by examining Accuracy performance, there was a main effect of Condition ($F(2,84) = 10.84$, $MSE = .03$, $p < .001$), with the associative encoding condition leading to greater accuracy performance than both the deep ($t(53) = 3.55$, $p = .04$) and the shallow ($t(57) = 4.16$, $p < .001$) conditions, although there was no difference between the shallow and the deep conditions ($t(64) = 1.28$, $p = .20$). There was also a main effect of Age on accuracy ($F(1, 84) = 8.27$, $MSE = .03$, $p < .01$), with older adults in general performing poorer than younger adults (see Table 3). The Condition X Age interaction was not significant ($F(2, 84) = 2.30$, $MSE = .03$, $p = .11$).

Table 4: **Experiment 3.** Recognition Task Performance in Between-subjects Design by Condition with Neutral Context Picture. Standard deviations in parentheses.

Condition	Shallow		Deep		Associative	
Measure	Young	Old	Young	Old	Young	Old
Hit Rate	.68 (.17)	.56 (.20)	.68 (.12)	.67 (.14)	.77 (.11)	.75 (.14)
False Alarm Rate	.08 (.09)	.16 (.26)	.09 (.09)	.13 (.14)	.04 (.07)	.07 (.06)
Accuracy	.60 (.12)	.40 (.21)	.59 (.12)	.54 (.19)	.73 (.11)	.68 (.18)

3.1.3 Discussion

The Hit Rate performance showed a main effect of Condition. Although there was no main effect of Age or interaction of Condition X Age, if you examine the graph (see Figure 7), you can see that the Hit Rate performance for the older adults follows the predicted LoP finding, with associative still being the highest. However, with the younger adults, there is clearly no difference still between the shallow and deep condition.

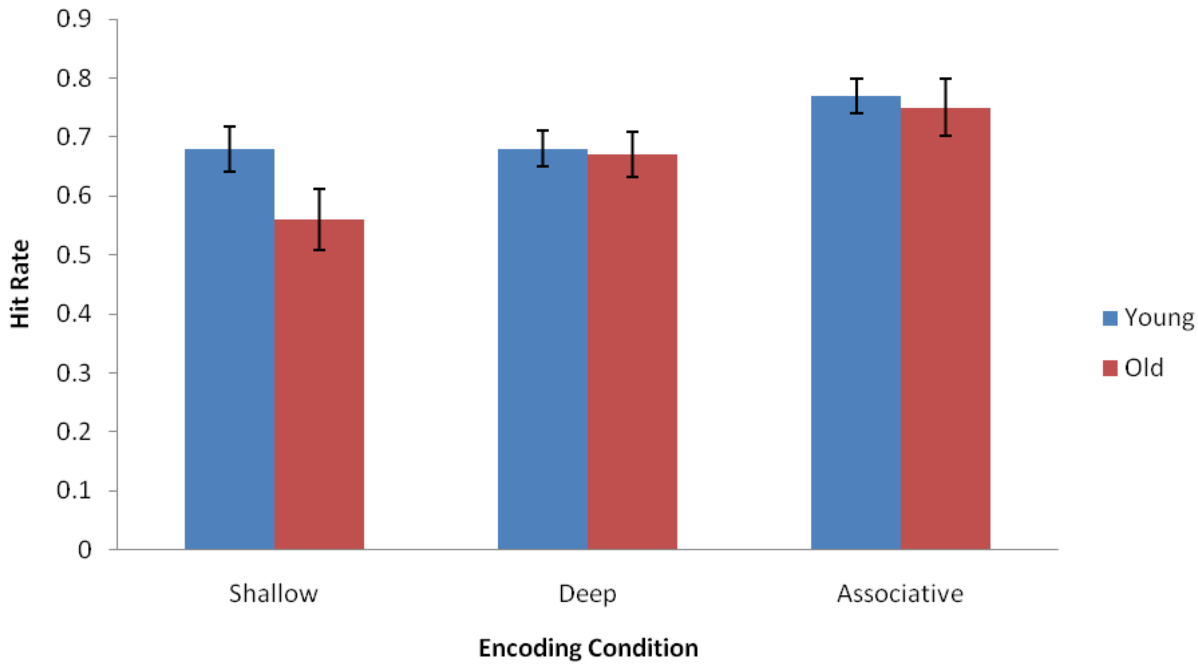

Figure 7: **Experiment 3.** Age Comparison of Hit Rate by Condition with Neutral Context Pictures in Between-Subjects Design. Error bars represent SE.

For this extension of Experiment 1, there was no main effect of any of the variables on the False Alarm Rates (see Figure 8), although if you examine the Figure 8 it is clear that the number of false alarms for the older adults is the highest with the shallow condition, then decreases with the use of a deep encoding condition, and then decreases further still with the associative encoding condition. For the younger adults, in this aspect of the performance data, there is still no discernable difference between the deep and shallow conditions, although they also show the fewest false alarms in the associative encoding condition.

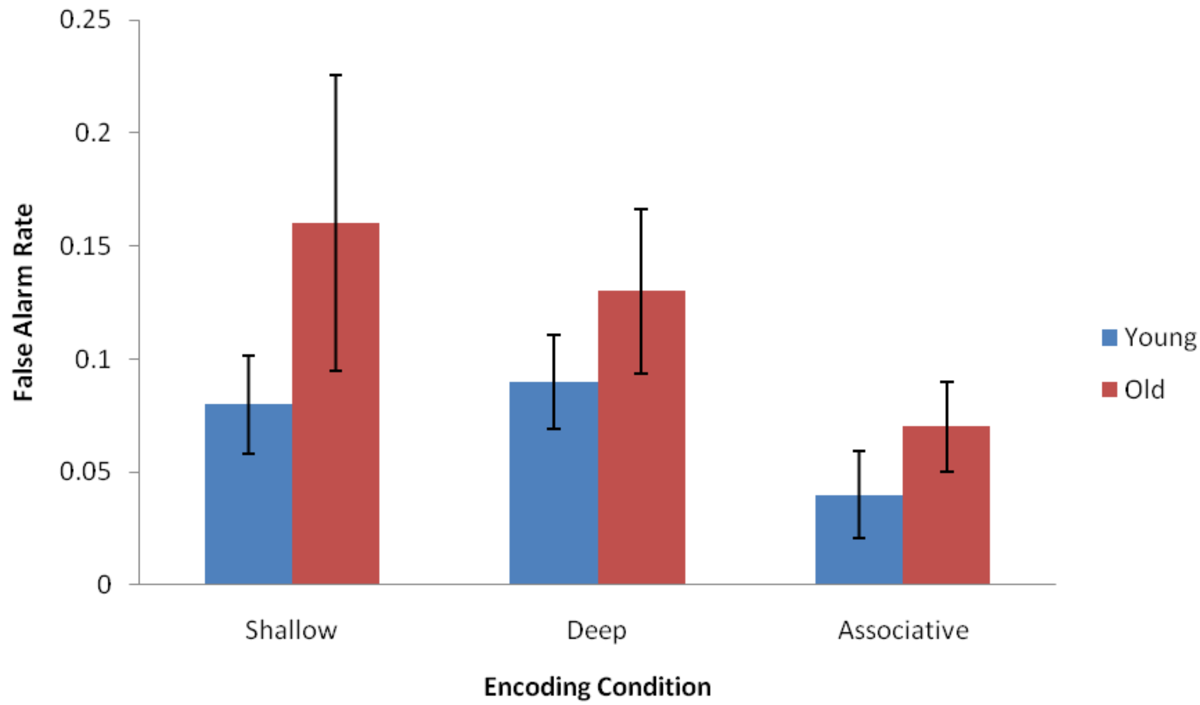

Figure 8: **Experiment 3.** Age Comparison of False Alarms Rate by Condition with Neutral Context Pictures in Between-Subjects Design. Errors bars represent standards errors of each age group in each respective condition.

Although the Condition X Age interaction was not statistically significant, visual depiction of the results (see Figure 9) indicates that the older adults were following the predicted pattern of results, with the deep encoding condition having better accuracy than the shallow, and with the associative still showing the best performance overall. The younger adults showed a persistent lack of a LoP effect with again no difference being found between the deep and shallow encoding conditions.

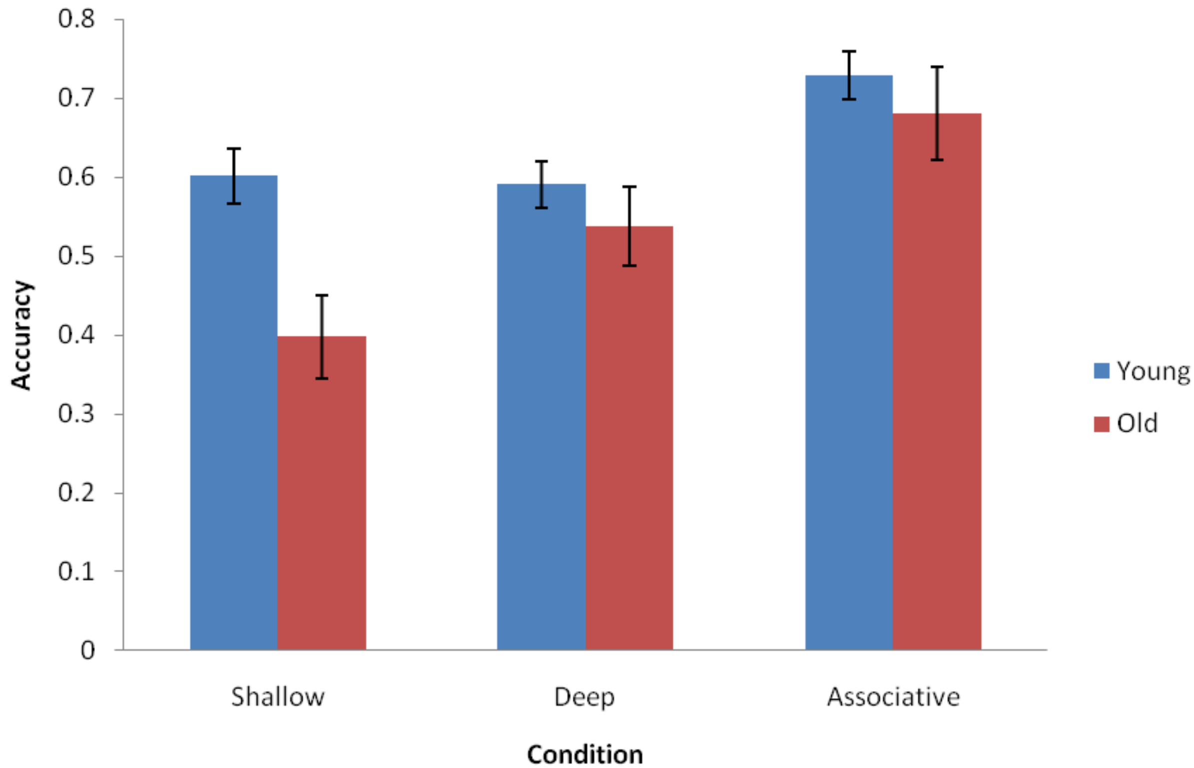

Figure 9: **Experiment 3.** Age Comparison of Accuracy Performance by Condition with Neutral Context Pictures in Between-Subject Design. Error bars represent the SE of each age group in each respective condition.

In summary, the main finding is that once again the associative encoding condition led to the best memory performance for both groups compared to the other two encoding conditions. Although there is an increasing disparity between the performance of the older and younger adults compared to Experiment 1, the between-subjects extension of Experiment 1 did not produce a pattern of results statistically different from the within-subject results, nor did using a between-subjects design produce for a statistically significant LoP effect or interaction between younger and older adults.

3.2.1 Experiment 4 (extension to Experiment 2) - Method

Participants

A set of 54 healthy undergraduate students (38 female) from the University of Waterloo received course credit for participation in the study, with three groups of 18 students each completing one of the three different study conditions. In addition, older adults from the WRAP participant pool (described earlier) also participated, receiving token monetary remuneration for their participation, with 14 completing the deep encoding condition and 10 completing the associative condition. For comparison, data from performance in the shallow condition from 27 seniors from Experiment 1 were included here. In both the current experiment, and the one described above, the seniors in the deep and associative conditions completed that condition in both the extension to Experiment 1 (with neutral images) and the extension to Experiment 2 (with emotional images), with the order of experiment counterbalanced across participants. To try to ensure that the two sessions remained as distinct as possible, these older adults were given a 10-15 minutes break between experiments, and given a tour of the main lab area in between test sessions.

The mean age of the young adults tested in Experiment 4 was 21.83 (*SD* = 1.87, range = 17–23), and the mean age of the older adults was 73.98 (*SD* = 7.64, range = 61-89). The mean number of years of education was 13.95 (*SD* = 1.59) for the younger adults and the mean years of education for the older adults was 15.24 (*SD* = 3.61), which differed significantly ($t(42) = 6.27$, $p < .01$). All participants were fluent English speakers, and had normal or corrected-to-normal hearing and vision. The National Adult Reading Test – Revised (NART-R) was also administered to allow an estimate of Full Scale IQ (FSIQ), based on number of errors in pronunciation during vocabulary reading (Blair & Spreen, 1989; Nelson, 1982). The young participants had mean FSIQ estimates of 104.54 (*SD* = 7.58) and the older adults had a mean FSIQ of 117.30 (*SD* = 7.49), which differed significantly ($t(58) = 4.84$, $p < .001$).

Materials

All of the materials and stimuli used were identical to the materials used in Experiment 2, described previously.

Procedure

The procedure for each of the conditions was identical to that for Experiment 2. The only difference was that, for the young adults, there were three randomly assigned groups of 18 participants, and each group completed only one of the encoding conditions. For the older adults, data for the shallow encoding condition were re-used from the shallow condition data of Experiment 2 seniors, since this condition was always completed first. Also, 14 naïve seniors completed the deep encoding condition and 10 completed the associative encoding condition.

3.2.2 Results

A multivariate ANOVA was conducted with Hit Rate, False Alarm Rate, and Accuracy entered as the dependent variables, and with Condition and Age entered as between-subjects factors.

Hit Rate

The ANOVA indicated a main effect of Condition ($F(2, 97) = 18.65$, $MSE = .02$, $p < .001$), with the associative condition having higher Hit Rates than the shallow condition ($t(68) = 6.19$, $p < .001$), and the deep condition ($t(74) = 4.17$, $p < .001$). This time the deep condition led to significantly higher Hit Rates than the shallow encoding condition ($t(74) = 1.98$, $p = .05$). There was no main effect of Age ($F(1, 97) = 0.16$, $MSE = .02$, $p = .69$), and no Condition X Age interaction ($F(2, 97) = 1.39$, $MSE = .02$, $p = .26$) (see Table 4).

False Alarm Rate

There was a main effect of Condition on False Alarm Rates ($F(2,97) = 4.13$, $MSE = .01$, $p = .02$), with the associative encoding condition leading to significantly lower False Alarm Rates than the shallow condition ($t(68) = 3.32$, $p < .001$), but it was not different than the deep condition ($t(57) = 1.38$, $p = .37$). There was also a significant difference between the shallow and the deep conditions ($t(74) = 2.33$, $p = .02$). There was also a main effect of Age ($F(1, 97) = 12.09$, $MSE = .01$, $p = .001$), with the older adults performing significantly poorer than the younger adults. The Condition X Age interaction was not significant.

Accuracy

When examining the effect of Condition on memory accuracy (see Table 4 for means) there was a main effect of Condition ($F(2,97) = 40.89$, $MSE = .01$, $p < .001$), with the deep condition being significantly better than the shallow condition ($t(78) = 5.89$, $p < .001$), and the associative condition was better than both the deep condition ($t(60) = 2.14$, $p = .02$) and the shallow condition ($t(74) = 7.57$, $p < .001$). There was also a main effect of Age ($F(1, 97) = 9.78$, $MSE = .01$, $p < .01$), with the older adults performing poorer than the younger adults.

Table 5: **Experiment 4.** Recognition Task Performance in Between-subjects Design by Condition with Emotional Context Picture. Standard deviation in parentheses.

Condition	Shallow		Deep		Associative	
Measure	Young	Old	Young	Old	Young	Old
Hit Rate	.59 (.16)	.60 (.14)	.72 (.14)	.75 (.14)	.82 (.08)	.82 (.08)
False Alarm Rate	.10 (.11)	.17 (.11)	.07 (.07)	.12 (.09)	.003 (.05)	.03 (.05)
Accuracy	.48 (.11)	.43 (.12)	.65 (.12)	.63 (.15)	.78 (.09)	.79 (.09)

3.2.3 Discussion

When we examined the Hit Rates for this extension to Experiment 2 (see Figure 10), it is remarkable to note, that for the first time, unlike the three previous experiments, the older adults are on par with the younger adults in terms of Hit Rates for first two conditions, with very little difference apparent in the associative condition. Also, although the younger adults seem to increase their Hit Rate from the shallow to the deep, and again in comparison from the deep to the associative, the older adults seem to increase in Hit Rate comparing deep to shallow, but there is no increase in Hit Rate from deep compared to associative, which may potentially indicate a ceiling effect in the older adults.

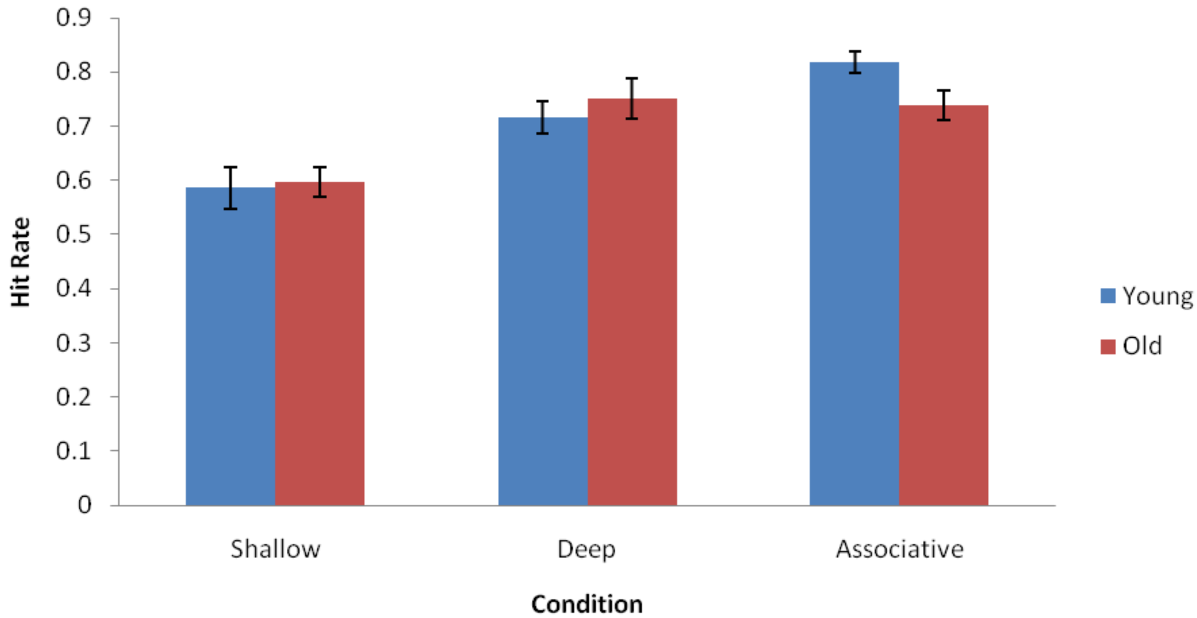

Figure 10: **Experiment 4.** Age Comparison of Hit Rate by Condition with Emotional Context Pictures in Between-Subjects Design. Errors bar depict SE.

When the False Alarm data are depicted graphically (see Figure 11), it is readily apparent that there is a consistent trend of decreasing False Alarm Rates from shallow to deep and again from deep to the associative condition, at approximately the same rate of decline for both younger and older adults. Combined with the Hit Rate data, this pattern indicates that the different encoding conditions progressively improve memory performance both by increasing the Hit Rate during the task as well as by decreasing the amount of False Alarms made during the task.

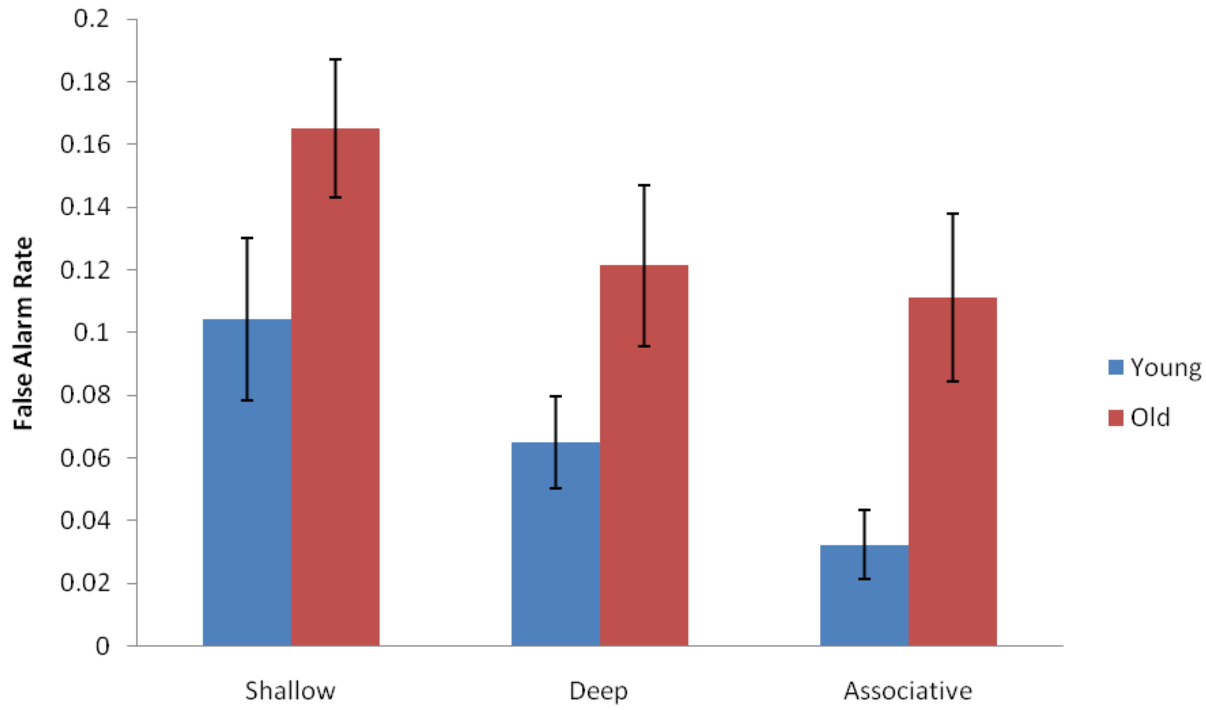

Figure 11: **Experiment 4.** Age Comparison of False Alarm Rate by Condition with Emotional Context Pictures in Between-Subjects Design. Error bars depict SE.

Predictably, then, given the other data, the accuracy data exhibits the originally hypothesized pattern (Figure 12), with a nice traditional LoP effect with both the younger and the older adults. In particular, it has been the consistent finding throughout all of the 4 experiment described in this thesis thus far, the associative encoding condition led to the best memory performance with both age groups in all of the different versions of this experiment that were conducted, even better than a traditional LoP encoding manipulation.

The marginally significant interaction appears to have been due to the significant increase in accuracy for the young adults from the deep compared to the associative condition, whereas for the older adults, they did not perform much better in the associative compared to the deep condition. This may be indicative of the older adults, in a between-subjects design, with the benefit of emotional context stimuli at encoding, possibly having reached their ceiling of performance in this memory testing paradigm, since all of the previous versions of this paradigm have showed a reliable benefit from associative compared to the deep condition.

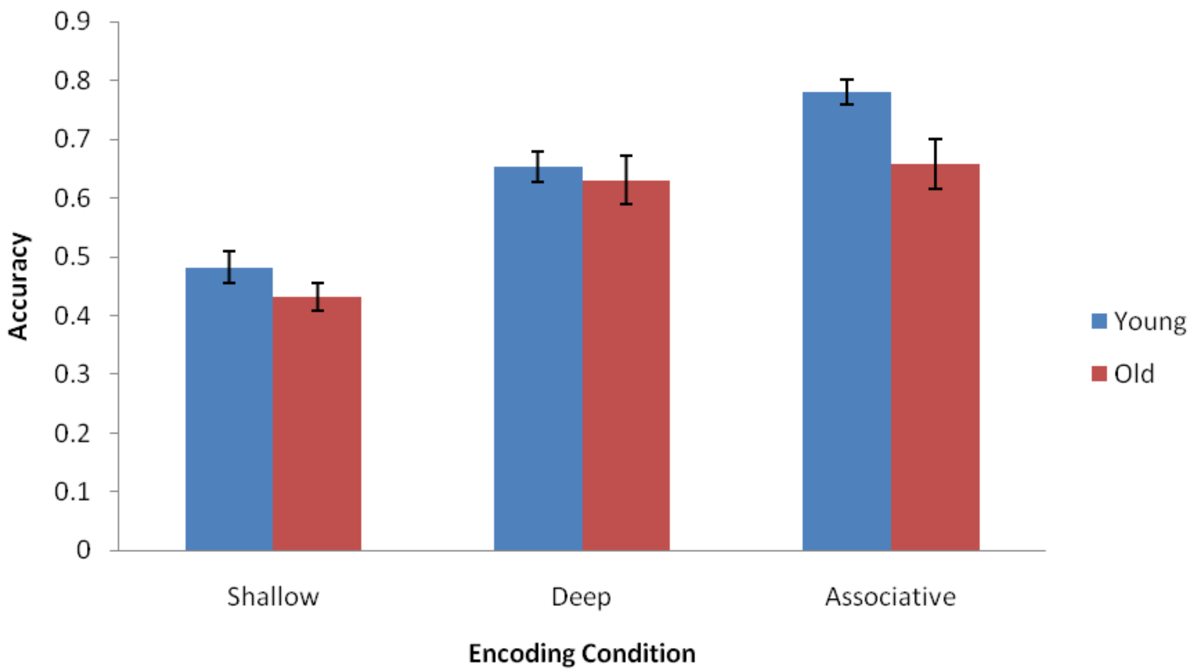

Figure 12: **Experiment 4.** Age Comparison of Accuracy Performance by Condition with Emotional Context Pictures in Between-Subjects Design. Error bars represent SE.

3.3 General Discussion of Experiment 3 and 4

When examining the patterns of data generated by these two extensions to Experiment 1 and 2, it would appear that the older adults did not need a wide range of emotional valence in their context to make the deep encoding task meaningful enough to elicit a traditional LoP effect of deep proving better than shallow levels of processing. For all of the experiments except for Experiment 2, the memory performance for seniors was better in the deep than the shallow encoding condition. On the other hand, for the younger adults, it was not until Experiment 4 that they exhibited the traditional LoP effect – in the other experiments the deep encoding condition led to lower or equal accuracy compared to the shallow encoding condition.

Both groups showed a consistent benefit in the between-subjects design when they only had to do one type of encoding manipulation compared to the within-subject design (see highlighted values below in Tables 6 and 7), meaning that there was some effect of either fatigue and/or order effect interfering with the memory results in Experiments 1 and 2.

In summary, we demonstrated the unique finding in Experiment 4 that even if the encoding manipulation is applied to context information, rather than the item being tested, there is still a memory benefit on later item memory by using deep levels of processing. Given the previous findings in our laboratory of the benefit of merely having meaningful context present at encoding assisting memory, this series of experiments highlights that memory performance cannot only be benefitted by the presence of meaningful context, but that the context can be intentionally encoding along with the target item of interest to show consistent memory improvements. However, more significantly even than that, we demonstrated that the use of an associative encoding instruction has the potential to benefit and aid memory performance even more than a deep levels of processing manipulation, and that this benefit applies equally to both younger and older adults. How these findings relate to the binding hypothesis and the associative deficit hypothesis, the LoP literature, and associative memory research will be elaborated in the General Discussion of Ch 4.

Table 6: Comparison of Accuracy Performance between Young Adults in the Within- and Between-Subjects Designs

Neutral Context	Experiment 1	Experiment 3	Emotional Context	Experiment 2	Experiment 4
Shallow	.58 (.16)	.60 (.12)	Shallow	.51 (.25)	.48 (.11)
Deep	.50 (.15)	.59 (.12)	Deep	.51 (.23)	.65 (.12)
Binding	.72 (.19)	.73 (.11)	Associative	.72 (.14)	.78 (.09)

Table 7: Comparison of Accuracy Performance between Older Adults in the Within- and Between-Subjects Designs

Neutral Context	Experiment 1	Experiment 3	Emotional Context	Experiment 2	Experiment 4
Shallow	.41 (.20)	.40 (.21)	Shallow	.39 (.15)	.43 (.12)
Deep	.45 (.23)	.54 (.19)	Deep	.39 (.18)	.63 (.15)
Associative	.58 (.22)	.68 (.18)	Associative	.49 (.17)	.79 (.09)

Chapter 4
General Discussion

As described earlier, memory is not one distinct item or unit, but rather a holistic recreation of an event in varying degrees of detail, and the existence of a memory derives from our need to cognitively maintain an ongoing mental representation of our environment (Glenberg, 1997). In much the same way as our eyes can move about and vary what we perceive visually in various levels of details, committing some events to the periphery whereas others are focused at the centre, so also can we think of our memory as our mental perception or representation of what our attention has put in focus and in the periphery. We also know from various lines of research that our memory can be modulated by aspects such as emotionality (Kensinger & Corkin, 2003) and novelty (Tulving & Kroll, 1995).

4.1 Context Effects

As discussed in the introduction, early research into how we remember what has happened to us led to the realization of the context reinstatement effect, and led to increased investigation of the effect so context on memory and the role that context can play in helping memory performance.

The temporal context model (Howard & Kahana, 2002) incorporates two important theoretical aspects of memory retrieval, those being that our memory systems are able to recreate or to reinstate previous contextual experiences. Traditionally, when context effects are tested, there is a manipulation of same vs. different context between encoding and retrieval. However recent work in our laboratory identified that even simply having meaningful context present at encoding, without reinstating a context at retrieval, still confers a measurable benefit to having meaningful vs. meaningless context information available at encoding (Skinner & Fernandes, 2009).

The results of our study extend the work of Skinner and Fernandes (2009) by demonstrating that the presentation of context information at encoding can lead to marked improvement in later memory performance, and indeed that even when specific encoding questions are used to draw attention to different aspects of the context while memorizing an item, this still leads to a later benefit in item memory.

In relation to the temporal context model (Howard & Kahana, 2002), it would seem, therefore, that the encoding manipulations we conducted on the context information presented concurrently with the items to be memorized, modulated to varying degrees the demarcation of the various ‘telephone poles’ in the past road behind us and assisted in item memory retrieval to varying degrees depending on how well the telephone poles were demarcated and how closely the item information was associated to the contextual cues. To use this model as an example, in the shallow condition we would expect very little novelty or ease of demarcation of the ‘telephone poles’ of these events, and further still, that once we identified the event using the contextual clues we still remembered, since only shallow level processing was engaged, there would be few associative pathways to follow to ‘find’ the desired memory of the item. With the deep encoding condition, more associative pathways are theoretically formed, since this encoding question drew on emotionality which would be expected to engage the amygdala, frontal lobes and other emotion sensitive areas of the brain within the formation of associates around the ‘telephone pole’ that is the event. This allows for more pathways to more efficiently mentally ‘find’ the item being asked about in the retrieval session. Our associative encoding question which asked participants if the context scenes matched the target words would have required the participant to search through their existing memories about what is normal and what has been seen before and then compare whether the particular item-picture set match. In a way this could be seen as forming links and mental pathways much further out into our long term memory stores, and therefore leading to the most efficient networks of associations for the sake of later item retrieval.

In relation to context effects, we were able to replicate the previous findings of our laboratory (Skinner & Fernandes 2009; 2010) which demonstrated that an instruction to actively engage in the formation of associations between item and context at encoding leads to better item memory performance, even if the context used at encoding was not again reinstated at retrieval. The main difference of the current set of studies from the previous studies in our laboratory was that the context scenes used were pictures of scenes and events, rather than faces of people, which perhaps allows the results to be more generalizable. Also, we demonstrated through a comparison of both deep and shallow encoding instructions in addition to an associative instruction that the instruction to engage in association between item and context led to the best improvement in memory performance, even over and above the benefit of a deep encoding condition. This effect was true in older adults, and has implication for the development of compensatory strategies to help older adults alleviate common memory deficits which accompany normal aging.

4.2 Cognitive Aging and Binding

As the brain ages, there are numerous changes that occur within the brain, such as the reduction in axonal integrity throughout the networks across the brain and the decrease of gray matter, white matter hyper intensities, de-differentiation, reduced lateralization, and activation of compensatory regions (Charlton et al. 2009, ; Minati, Grisoli, & Bruzzone, 2007; Cabeza et al. 1997). All of these different changes in the brain result in a reduced ability to form new connections and to activate pathways that have already been established, resulting in increasing difficulty with age in performing accurately on retrieval tasks. As we had discussed in the introduction, a major aspect of this set of experiments was to examine encoding strategies which could be used to help compensate deficits in memory associated with these increasing neurological changes.

One of the main aspects of this set of studies is to examine whether there are strategies that can be utilized that would allow older adults to compensate for the increasing neural changes that accompany aging. As discussed earlier, Cabeza (1997) demonstrated that young adults exhibit unilateral activation during a memory task, whereas high-performing older adults activate more regions by exhibiting bilateral activation of brain regions, with has been explained as the aging brain`s natural compensatory mechanism and referred to as the HAROLD (hemispheric asymmetry reduction in older adults) model. This suggests that the aging brain is in some cases is capable of adapting in order to maintain cognitive performance.

In relation to the behavioral finding that we demonstrated, especially those indicated in Experiment 4, we believe that the ability of the different encoding manipulations to successfully increase memory performance in older adults is due to the manipulations ability to, in a way, force the older adults' brain to recruit bilateral regions for completion of the task. This is done because the more the encoding question requires the formation of associations, the more areas of the brain have to be involved. As such, we would expect that if Experiment 4 (the extension to

Experiment 2) were conducted while fMRI brain scans were being taken of the participants as they completed the encoding and retrieval tasks, then the associative condition would lead to more bilateral brain activation in the seniors than either of the LoP conditions, and that it is also likely that the deep LoP condition would lead to slightly more bilateral activation than the shallow condition. Therefore, our interpretation of our data is that the behaviour we demonstrated in this series of studies should correlate strongly with increasingly bilateral brain activation in the older adults, but further studies would be necessary to investigate if this were the case.

In regard to the younger adults, Cabeza et al. (2002) demonstrated that they did not need to engage bilateral activation of brain regions to perform the task well. Since the younger adults brain still has very quick and efficient neural connections relative to that of older adults, and their neural processing speed has not been compromised as in older adults (Salthouse, 1996), I would expect that the younger adults would show an increase in activation in the emotionally sensitive regions with the deep encoding condition and greater overall activation of the brain with the associative condition, but still exhibit primarily unilateral activation.

It is also argued that the increasing inability to bind different features of a memorial experience together, so that at retrieval they are still associated with each other, is a major source of older adult memory performance deficits (Chalfonte & Johnson, 1996). This idea was elaborated by Naveh-Benjamin (2000) in which he proposed his associative deficit hypothesis, which hypothesizes that older adults suffer from a deficit in forming and retrieving links between different units or features of a memory, such as the item and the context, and that older adults` performance is therefore dependent on the extent to which a cognitive task requires these links.

Younger adults spontaneously form and utilize these associations, whereas older adults exhibit a reduced ability to spontaneously engage in the forming of and consequent use of associations (Naveh-Benjamin, 2000).

The current set of studies endeavored to replicate and extend the recent research demonstrating that when older adults are specifically instructed to form associations between the item and the context, they *are* able to do so, and if that association is used again at retrieval, memory performance in older adults is significantly improved (Skinner & Fernandes, 2009; 2010). By logical deduction, if a memory encoding instruction designed to compensate for this particular hypothesized deficit leads to a greater boost in memory than other encoding instructions, than this deficit must be greater than those which may be addressed by the other encoding instructions. We found across all of our experiments, despite differences in patterns and results in the shallow and deep encoding conditions, that every time in both older and younger adults, the associative encoding condition led to the best memory retrieval performance, caused by both an increase in correct Hits at retrieval and a reduction of False Alarms. Further investigation would be required to determine if this type of encoding manipulation benefits older adults more than younger adults.

4.3 Levels of Processing

One of the most common strategies that is taught to improve memory in undergraduate classrooms is the idea of levels of processing, and the well known benefit of ‘deeply’ encoding information to remember it better. Since early on in the field of psychology, there are many different approaches and strategies that have been used to actively improve memory performance, and one of the most influential psychological papers in the 20th century was the publication by Craik and Lockhart in 1972, describing a proposed framework for the study of memory research referred to as the levels of processing (LoP) effect. This framework proposed that memory retention is a function of depth of processing, and that various factors, such as the amount of attention devoted to a stimulus, its compatibility with the analyzing structures, and the processing time available, will determine depth of mental processing (Craik & Lockhart, 1972). For the purpose of our task, we decided to use the two opposite ends of the LoP framework for the comparison, and we utilized these encoding manipulations in relation to the context pictures instead of the target words, which is typically the case.

We were interested in examining whether the type of encoding that the brain engages in when doing a traditional LoP manipulation is limited to the item on which the encoding was focused (which would mean the benefit is only realized by the item the encoding was focused on), or if the brain engages in the type of processing being triggered in relation to everything in focus during an encoding task, not just the one specific item being tested. To address this, we used the traditional LoP manipulations for memory tasks, except the manipulations were focused toward context pictures which were presented concurrently with the target words which the participants were instructed to also memorize and later recall without the context being present. In this design, we demonstrated the unique finding that even though the encoding manipulations were not directly focused on the items being tested, the participants still showed a LoP effect, most notably in Experiment 4 which seems to indicate that the brain engages in the type of processing triggered by the encoding manipulations in a more general way than initially thought, and that it is possible to have improved memory for more than just the target items if a deep LoP manipulation was being utilized.

Limitations

One of the main limitations in the current set of studies is that a unique group of older adults was not run through each of the different encoding conditions and Experiment types, due to difficulty in availability of seniors in the participant pool who had not participated in some version of the study already. It would be better for the sake of comparison to have run the older adults in the same manner as the young adults were run in both Experiment 3 and 4. Also, at the time of this write-up, the full complement of seniors were not yet completed in Experiment 3 and 4 in the deep and associative conditions, although enough were run that we would not expect adding to the number to change the pattern of results in any significant way, other than to make the significance of the patterns demonstrated stronger still.

It was not realized until after the data collection had been completed that there was a confound in the data collected from the seniors in Experiment 3 and 4 in the deep and associative conditions. When the neutral context pictures were selected, only pictures with a valence and arousal rating of between 4.0 and 5.99 were utilized. However, in the experiment versions using emotionally valenced context pictures, the database did not yield enough pictures that were neutral on arousal but positively and negatively valenced below the rating of 4.0 and above 5.99, so the criteria were moved to include some more pictures while still having pictures at both ends of the valence spectrum, resulting in a pictures being selected which were neutral in arousal but rated on valance from 1-4.2 and from 5.7-9.

As such there was a slight overlap (4 pictures) in the context pictures used in the neutral and emotional versions of the experiment. This did not impact any of the participant data collected in experiment 1 or 2, since they were completely different sets of people and they would never have experienced the overlap, nor did it affect the participant data collected from the younger adults in Experiment 3 and 4, since unique groups of younger adults were run in each of the Experiment types and in each of the conditions. However, the older adults run in the deep and associative conditions in Experiment 2 and 4 completed both experiment versions of the same condition type meaning that, for these participants, they experienced the overlap in the presentation of context pictures used, which, even though the order was counterbalanced, may have affected their memory results.

Another limitation that should be addressed is to examine performance in the older and younger adults with context and item words being presented concurrently but no encoding instruction being given. This would serve to examine how free viewing memory performance compares to the encoding manipulations that were used in this set of experiments to ensure that in some cases having an instruction does not actually impede memory performance by placing a task demand on the participants, and to further extend the finding to be able to demonstrate how much better memory performance can be with the use of encoding strategies compared to without. For our set of experiments we only compared different encoding strategies, so it might be useful to do have a condition as described above in order to get a sort of control measure for both age groups.

Future Directions

The main finding of our set of studies was that an instruction to engage in the formation of associations led to the most significant memory improvement in both the younger and the older adults. Most importantly, this has implications for memory rehabilitation research, which seeks to utilize different encoding strategies to aid older adults in compensating for the natural decline in memory performance due to aging. Further research is necessary to investigate the best was to incorporate an associative encoding manipulation into workable memory rehabilitation techniques. It is clearly evident that memory can be improved with the use of encoding strategies, and this continues to be any area in greater need of research to utilize these finding to assist our aging populations and eventually, ourselves as well, as aging is something all people face.

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