Uncovering the Mechanisms which Underlie the Integrative Advantage in Healthy Aging

Pritha Dhir

Department of Psychology, City, University of London

October 2016

Thesis submitted in partial satisfaction of the requirements for the degree of Doctor of Philosophy (PhD) at City, University of London

Contents

List of figures and tables

Acknowledgements

First and foremost, I would like to thank my supervisor, Dr Marie Poirier for her constant support, encouragement and motivation throughout the years. Her wise words and expert supervision, together with her lovely disposition, kept me focused and on target to completion. A huge thank you to all my friends and colleagues at City, University of London, whose encouragement and support were greatly appreciated. Finally, my warmest thanks go to my family; without their constant love and belief in my abilities, this PhD would not have been a possibility.

Declaration

I grant powers of discretion to the University Librarian to allow this thesis to be copied in whole or in part without further reference to me. This permission covers only single copies made for study purposes, subject to normal conditions of acknowledgement.

Abstract

The current thesis aimed to investigate associative memory performance of older and younger adults through various manipulations involving unrelated and integrative word pairs (pairs that can form a sole concept). Research indicates that older adults demonstrate an associative deficit whereby they have difficulty forming new associations between items (Naveh-Benjamin, 2000), and this age-related deficit is attenuated when associative memory can be supported by prior knowledge or pre-established associations, such as semantically related word pairs (Badham & Maylor, 2015; Castel, 2005). However, findings from Badham, Estes and Maylor (2012) suggested that word pairs which lack prior associations but can be integrated lead to a reduced associative deficit in the elderly. This thesis first tests the robustness of the integrative advantage as an empirical result; it then attempts to uncover the mechanisms through which the integrative advantage manifests itself. Experiment 1 set out to replicate Badham et al. (2012) and produced similar findings, in that pairs which were integrative but which lacked pre-established associations were better recalled by the elderly than unrelated pairs (an integrative advantage), consequently reducing the associative deficit. Experiments 2, 3a and 3b then examined the roles of item-specific and relational processing and found that encouraging item-specific processing with the integrative pairs reduced their advantage, to the extent that they were not recalled significantly better than the unrelated pairs. Experiment 4 intended to assess whether interactive imagery played a role by seeing if the integrative advantage would be reduced with the encouragements of interactive imagery techniques of the unrelated pairs. Results demonstrated that the advantage was still maintained, which led to the possibility that specificity and perhaps uniqueness were involved. The final experiment investigated the influences of cue overload on integrative and unrelated recall, as well as on recognition. Findings indicated that overloading the integrative cues and hence making the relationship less specific reduced the integrative advantage relative to a condition where the integrative pairs were not overloaded and were unique. In addition, older adults tended to rely more on familiarity than on recollection, in comparison to the younger adults, producing more false

alarms to the recombined pairs than their younger counterparts. Taken together, the results from the series of experiments conducted suggest that the role assignment model of relational concepts offers a viable explanation of how the integrative advantage can be explained. The introduction will outline the associative deficit hypothesis (Naveh-Benjamin, 2000) as well as the reduced resources hypothesis of cognitive aging (Craik, 2002), before moving on to the empirical chapters. The latter cover more specific literature relating to each of the factors/specific phenomena of interest.

Chapter One: General introduction

Aging is associated with declines in many cognitive domains, such as episodic memory, mental speed and executive functioning (Craik & Salthouse, 2008). Research has indicated that older adults often show difficulties on tasks requiring attention and executive abilities (Hasher & Zacks, 1988; Jennings & Jacoby, 1993). Executive functions can be described as 'high-level processes involved in monitoring and controlling responses…such as resisting impulses, and overriding dominant tendencies…' (Apfelbaum, Krendl & Ambady, 2010, pg 1074). A study by McDowd, Oseas-Kreger and Filion (1995) demonstrated the consequences of declining executive functioning in the elderly; in particular, on their capacity to inhibit e.g. managing intrusive thoughts, processing irrelevant and relevant information at the same time.

Throughout the thesis, various terminological distinctions are made so a brief overview will now be provided. Explicit (or declarative) memory refers to memories that can be consciously recalled and involves the memory of facts and events. Explicit memory can be subdivided into episodic and semantic memory. Episodic memory is described as memories of personal, everyday experience, whereas semantic memory can be conceptualized as a more structured account of meanings, facts and knowledge about the world that we have acquired (Fuentes & Desrocher, 2013; Tulving, 1972). Recognition memory is a subcategory of declarative memory, and involves recognizing previously encountered objects, events or people. It can be further subdivided into two component processes: familiarity and recollection. Familiarity occurs in the absence of recollection, and is the feeling that the event was experienced previously i.e. knowing. On the other hand, recollection involves the retrieval of aspects associated with the previously encountered event i.e. remembering. Implicit memory (antonymous to explicit memory) occurs unconsciously, and includes the memory of skills and how to do things, such as riding a bike. Relational memory relies on the encoding of similarities among a set of events e.g. categorised items, item memory focuses on the encoding of item-specific information such as rating each word for pleasantness, and associative memory can be viewed as learning and remembering the relationship between items. Encoding is a process which allows incoming information to enter memory, whereas retrieval involves accessing the stored information from memory so it can be utilised. In terms of ways to assess memory performance, recall tests the memory of items which were previously presented i.e. presenting a singular list of 20 words and asking participants to recall the 20 items as best they can. On the other hand, cued recall involves presenting pairs of items, with items on the left being the 'cues' and items on the right being the 'targets.' Participants are given a cue at test and required to recall its corresponding target, so involves assessing associative memory.

Normal aging is typically characterized by deficits in episodic memory performance, whilst appearing to be associated with relative strengths in other areas. Semantic and episodic memory have often been compared with each other in aging research because the former appears to be relatively intact (Rabinowitz, Ackerman & Craik, 1982) whilst the latter shows evidence of decline (Zacks, Hasher & Li, 2000). Numerous findings show age-related declines in episodic memory tasks (Bireta, Surprenant & Neath, 2008; Hoyer & Verhaeghen, 2006; Naveh-Benjamin, 2004), and research has attempted to shed light on the mechanisms believed to underlie these memory changes in adulthood. Currently, the most dominant and well-supported theory of episodic memory decline in the elderly is the associative deficit hypothesis (Chalfonte & Johnson, 1996; Naveh-Benjamin, 2000). Chalfonte and Johnson (1996) have argued that the poor memory performance of older adults partly arises from their difficulty binding together information into complex memories. They further suggest that a significant determinant of older adults' poor episodic memory is their deficient ability to create and retrieve links between single units of information, which is the basic premise of the associative deficit hypothesis (ADH). Research surrounding the ADH will now be discussed as the focus of the current thesis is the ADH and an empirical phenomenon that appears to challenge this hypothesis.

1.1 Associative deficit hypothesis (ADH)

According to Chalfonte and Johnson (1996) older adults have difficulty binding together information into complex memories, which appears to be the source of their episodic memory deficits. In their experiment, older and younger adults were shown items in different colours in 6x6 matrices, and their recognition memory of item, feature (i.e. the colour) and feature plus item information was tested. It was found that item or feature memory (remembering which items were presented or which colours were presented) was equivalent for both older and younger adults. However, when tested on item plus feature information (for example, remembering that an item was presented in a green colour), an age related deficit was found, despite preserved memory for item and colour information when tested separately. These findings suggested that the binding together of information underlies the source of the memory deficits observed in older adults (Chalfonte & Jonhson, 1996; Mitchell, Johnson, Raye, Mather & D'Eposito, 2000; Naveh-Benjamin, 2000).

Naveh-Benjamin (2000) extended this account and proposed the ADH, the basic premise of which is that older adults experience difficulties in creating and retrieving links between single units of information. These units can consist of two items; an item and its context; two contextual elements or 'the representation of two mental codes' (Naveh-Benjamin, 2000, p.1170). A significant determinant of the memory performance of older adults is the degree to which the memory task necessitates the use or creation of such associations. Therefore, the poor episodic memory documented by the aging population is believed to be due to problems in both encoding (creating) and retrieving associative information.

According to Naveh-Benjamin (2000), if memory for item and associative information is to be directly compared, the tasks chosen must require those processes with the difference being that one necessitates the encoding and retrieval of item information, whereas the other demands the encoding and retrieval of associative information. A procedure that involves these constraints was adopted by Glenberg and Bradley (1979). Typically, participants are presented with paired items for study; for the item test, some of the original items are presented alone (i.e. not in pairs); other new items are also presented and participants are instructed to recognise the old items. For the associative test, some intact pairs as well as recombined pairs are presented, and participants are asked to recognise the originally presented pairs. Such a procedure ensures that the same information is encoded during the study phase, and that participants are provided with all the associative and item information in the test phase. Therefore, it appears reasonable to assume that any observed performance differences between the two tests highlight differences in memory for item and associative information.

Naveh-Benjamin (2000) conducted a series of experiments examining the ADH account of episodic memory decline. In Experiment 1, older and younger adults were presented with word-non-word pairs for upcoming item and associative recognition tests. Compared to younger adults, older adults showed poorer recognition of associative information. In addition, they also displayed a deficit in their memory for non-words. This further supports the ADH because no pre-existing knowledge could be called upon to help with the encoding and retrieval of non-words, so older adults presumably had to attempt to make new associations between the letters of each non-word, which they struggled with. However, there is the possibility that the poorer associative memory exhibited by the older adults was due to very poor memory of the non-words. If this were the case, then it could be assumed that the sparse non-word memory of older adults prevented them from appropriately coming up with associative relationships between the words and non-words. On the other hand, such relationships were created successfully by the younger adults as both components (words and non-words) were encoded well. In order to rule out the possibility that older adults' associative deficit was the result of their poor memory of the components; the second experiment included the presentation of words only. We will come back to the second experiment after a brief comment about intentional and incidental learning.

One interesting question is whether older adults experience difficulties in their associative memory under both intentional and incidental learning conditions. In incidental learning conditions, participants are unaware that their memory performance is to be tested later on. On the other hand, intentional learning conditions involve participants being aware of and expecting a later memory test, therefore they encode the information intentionally (with the intent to remember). Neuropsychological models support the prediction that older adults' associative memory suffers in both incidental and intentional leaning procedures. Moscovitch (1992) formulated a neuropsychological model of memory which consists of a few components. According to Moscovitch (1992), the medial temporal lobes/hippocampus work automatically during incidental procedures by binding events together. The frontal lobes however, are required for more effortful processing; this system needs resources to engage in strategic information processing, which facilitates the encoding of information. Research suggests that these two systems do not perform at their best as we get older. Craik, Morris, Morris and Loewen (1990) found that old age affected tests which were believed to be mediated by the frontal lobes. Elderly participants were assessed on their ability to remember the source of the information they had just acquired (source amnesia). They were presented with 36 made up statements of public personalities, as well as 24 true statements. One week later, memory for the newly acquired facts was tested by a series of questions. After the questions, frontal lobe function was assessed by the Wisconsin Card Sorting Task (WCST) which is used to detect cognitive impairment. Furthermore, a verbal fluency test was administered as it is thought that an impaired ability to generate words from a specified category can be viewed as a sign of frontal dysfunction. Source memory was found to correlate reliably with score on the WCST and with verbal fluency, which also correlated with age, suggesting that source amnesia as a consequence of increasing age is associated with frontal lobe dysfunction. Davies and Bernstein (1992) showed that age had an effect on tests thought to be mediated by the hippocampal component. Older and younger adults completed the Tower of Hanoi (TOH) puzzle, which required participants to move a number of disks put on one of three pegs to another peg in a minimum number of moves. The TOH has been linked to the hippocampus and surrounding regions. Results indicated that the older the participants were, the more moves they needed to solve the puzzle. Therefore, when these findings are considered, one might reasonably predict that under intentional and incidental learning conditions, deficits in older adults' associative memory are likely to be present. Moreover, if the associative deficit were to be obtained only under intentional instructions, then one might conclude that the deficit was caused by some process related to intentional encoding.

Returning to Experiment 2 of Naveh-Benjamin (2000), the presentation of unrelated word pairs was involved. Study instructions were manipulated, whereby some of the participants anticipated an associative memory test and some an item memory test. A recognition test assessed item memory by presenting single items, half of which were studied and half of which were not. Associative memory was also tested by providing participants with either intact or recombined pairs, and asking them to select the original pairs encountered during the study phase. Findings reproduced the associative deficit of older adults, with the elderly participants demonstrating poorer memory performance in the associative test than in the item test compared to younger adults. Regarding the intentional and incidental learning conditions, when older adults were instructed to encode the single items, the memory deficit for associative information encoded incidentally was present. Furthermore, when older adults' attention was focused on associative information at encoding, no improvement in their associative memory performance was observed relative to the younger adults. On the other hand, the younger adults were able to remember more associative information under instructions to focus on it during study. This suggests that even when older adults are directed to pay attention to associative information during encoding, they are unable to benefit from its use as younger adults do. This could be thought of as coinciding with the view that older adults are unable to effectively encode associative information because of problems they have in engaging in appropriate strategies; perhaps they simply do not possess the necessary cognitive resources to deal with such demands when it comes to associative information. The reduced resource hypothesis of episodic memory decline will now be briefly discussed as it ties in with the ADH, and suggests that older adults' associative deficit stems from the fact that they have fewer cognitive resources than the younger adults to process and retrieve associative information.

1.2 Reduced resource hypothesis and the ADH

According to Craik (1983, 1986, 2002) older adults engage in self-initiated processing to a lesser extent than do younger adults. As a consequence, when environmental support is provided, older adults can be expected to benefit from its use, with greater environmental support resulting in greater gains in performance. Craik (1983) believed that remembering involves an interaction between internal mental states (i.e. self-initiated processing) and external information (i.e. stimuli and context). As older adults engage in less effective self-initiated processing (Craik & Byrd, 1982; Craik & Rose, 2011; Lindenberger, Marsiske & Baltes, 2000) their performance can be expected to suffer when such processing dominates a task such as free recall. Alternatively, older adults can be expected to do well when environmental support is provided at retrieval as in recognition tests. Because older adults are thought to have fewer processing resources available to them, self-initiated processing may be quite demanding, and as a result, performance suffers due to inability to cope with task demands. This view predicts that the more environmental support that is provided to older adults, the smaller the age differences observed between younger and older adults. Therefore, it could be expected that when free recall, cued recall and recognition are assessed, the largest age differences would be observed for free recall (because of lack of cues, and the greater need for self-initiated processing), smaller differences for cued recall (some environmental support) and even smaller ones for recognition (stimuli is provided so greater environmental support). However, the ADH would predict different outcomes, namely that the most age sensitive memory test is likely to be cued recall as it requires participants to encode and retrieve specific associations between the cues and targets, and this type of associative processing is impaired in older adults. In his fourth experiment, Naveh-Benjamin (2000) investigated the contrasting views of the ADH and the environmental support hypothesis. In this study, pair type was manipulated so that half the words pairs were semantically related (e.g., 'shirt sock') and half were unrelated (e.g., 'shoe bed'). It was expected that age differences would be markedly reduced with related pairs because of the pre-existing semantic support they provide, which could aid in both the encoding and retrieval process. Participants completed free recall, cued recall and recognition tests, and were aware of the later memory test so learning was intentional. Results highlighted older adults' poor memory performance for the unrelated pairs. In addition, in line with the ADH, the largest age difference was observed in the cued recall of unrelated pairs. According to the ADH, this occurred because the cued recall task involved the direct encoding and retrieval of specific and newly encountered associations, thought to be particularly problematic for the older adults. However, when semantically related pairs were used in the cued recall task, age differences disappeared altogether, presumably because new associations were not required for successful performance; participants could instead rely on pre-existing associations to support recall. No age differences were documented in any of the memory tasks when related pairs were used. This suggests that older adults are just as able as younger adults to retrieve recently encountered associations when prior knowledge can be relied upon to support performance. Thus, the series of experiments conducted by Naveh-Benjamin (2000) indicate that the poor episodic memory performance of the elderly can be attributed to their reduced ability to encode and retrieve new associations between units of information or elements within events.

In another series of experiments, Naveh-Benjamin, Guez, Bar-On and Hussain (2003) provided further support for the ADH; their first experiment aimed to extend the findings of the ADH by using pictures as opposed to words. Older and younger adults were presented with pairs of pictures at study, and their memory for each picture, as well as their associations to each other was tested afterwards. Each participant saw 28 pairs of simple objects, presented one at a time, and following the presentation of all pairs, item and associative recognition tests were administered. Associative recognition was employed instead of the typical cued recall test as it was thought that ‘cued recall, in addition to requiring associations, might also require other processes (e.g. the retrieval of the B item in an A-B pair)’ (Naveh-Benjamin et al., 2003, p.827). Therefore, it may be the case that some of the deficits obtained by Naveh-Benjamin (2000) could be related to differences in item availability.

The paired pictures were not semantically, visually or aurally related in any way. For the item recognition test, 8 original target pictures, as well as 8 distractors (which were initially not presented) were shown on the screen, and participants had to identify which target pictures had appeared during the study phase. In terms of the associative recognition test, 8 intact pairs were shown, along with 8 rearranged pairs, which were just as plausible as the intact pairs. Participants were asked to indicate which pairs were intact. An age effect was found, with younger adults performing better than the older adults, as well as a main effect of test, with performance higher on the item test than on the associative rest. Most importantly, compared to the younger adults, the older adults were disproportionally impaired on the associative test relative to the item test, thereby demonstrating their associative deficit. Experiment 2 tested the idea that the less reliance on new associations, the less pronounced the associative deficit of the older adults would be. Older and younger adults were presented with either unrelated or semantically related word pairs, and associative recognition was assessed along with item recognition. It was predicted that the associative deficit of the older adults would be reduced when the related pairs were used, as they would permit participants to rely more on pre-established associations and less on the creation of new ones. Participants saw 2 lists of 60 word pairs in total, with each list containing 30 unrelated or 30 related pairs. In contrast to the first experiment, forced choice item recognition was used, where the target word was paired with a distractor (either unrelated or semantically related depending on the condition), with participants being required to identify which word had appeared at study. This was used to equate the amount of information presented for each test item to the associative test. The item recognition test involved 24 original targets, each of which was paired with a related or unrelated distractor. The associative recognition test involved 24 intact pairs, 12 of which were related and 12 which were unrelated, as well as 24 recombined pairs, 12 which were recombined related pairs, and 12 recombined unrelated pairs. Participants were required to select the intact pairs. Similar findings emerged regarding the age effect and the test effect. Furthermore, for the older adults, memory for the unrelated pairs was disproportionally impaired with the associative test in comparison to the item test, whereas their performance for the related pairs did not show evidence of such a deficit with the associative test relative to the item test. Therefore, both experiments provide further support for the ADH using different stimuli (pictures) and associative recognition instead of cued recall. The experiments also indicate that the associative deficit portrayed by the elderly is not limited to verbal material. The older adults were disproportionally impaired in the associative test relative to the item test compared to the younger adults when unrelated pairs were used. This replicates previous findings that older adults experience difficulties in binding together single units of information (Bireta et al., 2008; Chalfonte & Johnson, 1996; Naveh-Benjamin 2000, 2002). In addition, the semantic relatedness of the items was found to reduce the associative deficit as older adults were able to rely on pre-established associations.

In an effort to show that older adults' associative deficit was not limited to words and/or pictures, Naveh-Benjamin, Kilb, Reedy and Guez (2004) investigated the ADH by using face-name pairs .The aim was to see whether the associative deficit would present itself when the materials portrayed information which was more meaningful and complex. Face-name pairs were used as they were an accurate depiction of everyday situations involving the meeting of people and their introduction to one another. It was thought that remembering the name of a specified face involved the integration of the specific name to the specific face. As the older adults have difficulty binding together single units of information, it was expected that they would portray considerable deficits in the associative recognition test relative to the item recognition test, compared to the younger adults. Each participant was presented with 40 face-name pairs one at a time on a computer screen. Following study, three memory tests were administered – two assessing item recognition (one for the names and one for the faces) and the other measuring associative recognition. The face and item recognition tests involved identifying the original targets from a selection of studied targets and distractors. The associative recognition test either involved the presentation of two faces with a name, with participants having to select the correct face which accompanied the name, or the presentation of two names with a face, with participants being required to choose the correct name which matched the face. Unsurprisingly, the younger adults performed better than the older adults, and memory for the face recognition test was significantly better than the name test, which in turn was better than the associative test. Of particular importance was the fact that whilst the older adults' performance decreased substantially from the name recognition task (M = 0.78, SD = 0.85) to the associative recognition task (M = 0.58, SD = 0.93), it decreased by a smaller magnitude for the younger adults from the name (M = 0.80, SD = 1.12) to the associative recognition test (M = 0.71, SD = 0.96). Moreover, a similar pattern emerged when the face and associative recognition tasks were compared – older adults' performance decreased more from the face task (M = 0.88, SD = 0.87) to the associative test (M = 0.58, SD = 0.93) relative to the younger adults (M = 0.92, SD = 1.21 for the face test and M = 0.71, SD = 0.96 for the associative test). Taken together, the findings indicate that older adults exhibit specific deficits in episodic memory for information of an associative nature and demonstrate the utility of the ADH, and how it is not limited to word-word or picture-picture associations.

Overall then, the consistent finding is that older adults' associative deficit can reliably be obtained in situations requiring them to form new associations, and that it can be reduced or even eliminated in circumstances where pre-established associations can be relied upon (Ahmed, Fernandes & Hockley, 2015; Cooper & Odegard, 2011; Fox, Baldock, Freeman & Berry, 2016; Mohanty, Naveh-Benjamin & Ratneshwar, 2016; Naveh-Benjamin, Maddox, Jones, Old & Kilb, 2011). In effect, such findings are indicative of how prior knowledge can benefit the episodic memory performance of the older adults.

1.3 Prior knowledge/schematic support

Research has indicated that older adults' episodic memory deficit can be reduced by providing them with environmental or external support (Craik, 1986; Craik & Jennings, 1992). Moreover, prior knowledge of a semantic nature or schematic support can help with the encoding and retrieval of to-be-remembered information, and as a consequence, memory performance can be improved (Badham & Maylor, 2015; Castel, 2005; Castel, McGillivray & Worden, 2013; Umanath & Marsh, 2014). For example, Badham and Maylor (2015) investigated the effects of congruency between the material encountered at study and the participants' knowledge on older and younger adults. Participants were required to associate the names of famous people to the faces of non-famous people, where the degree of similarity varied between the real famous faces and the non-famous ones. It was predicted that the older adults' associative memory would disproportionately benefit from prior knowledge/schematic support relative to the younger adults. A graded congruency effect was found, whereby the associations became easier to remember as the combinations were made to be more congruent with prior knowledge. Moreover, the older adults displayed more susceptibility to the effect than the younger adults lending support to the notion that older adults in particular are able to benefit from schematic support.

Castel (2005) tested the memory of older and younger adults for the fictional prices of grocery items, some of which were at market value and realistic (e.g. butter $2.99) and some of which were above/below market value and unrealistic (e.g. soup $14.39). Price type interacted with age where an age-related memory deficit was observed for the unrealistic prices but not for the realistic ones, suggesting that relying on prior knowledge as well as schematic support in the context of naturalistic and ecologically valid materials can result in older adults' associative memory performance being as good as that of the younger adults. Similarly, McGillivray and Castel (2010) discovered age-related deficits in memory concerning the unrealistic ages of faces but not concerning the realistic ages of faces again indicating how the associative deficit can be attenuated through the use of prior knowledge and schematic support. Information which is consistent or congruent with schemas is generally better remembered, and activation of the schemas can aid with the binding of information for older and younger adults (Besken & Gulgoz, 2009). When schematic support or prior knowledge is present within a domain, it may 'reduce the reliance on effortful, self-initiated processes (which may be detrimentally affected in aging) as well as enhance processing efficiency…all of which serve to enhance the ability to accurately remember information' (McGillivray & Castel, 2010, p.823).

1.4 Incidental encoding of new associations

The ADH assumes that age-related deficits in associative memory are due to difficulties in both the encoding and retrieval of associative information. However, research by Dew and Giovanello (2010) suggests that older adults can incidentally encode and retrieve new associations. Incidentally encoding items involves committing them to memory without conscious awareness of the fact that such items are going to be tested, and allows researchers to examine implicit influences on memory. For example, if one wanted to assess the impact of a particular manipulation on recall (e.g. depth of processing) without the influence of deliberate rehearsal/intent to learn, then one could adopt an incidental procedure by presenting a set of words and getting participants to perform tasks on them. As the main interest in this case is depth of processing, a shallow processing task could involve counting the number of enclosed spaces in the letters, whereas a deep task could involve thinking of free associates to each word. If a difference in recall is obtained between the two tasks, then one can assume that such an effect is the result of differences in depth of processing between the two tasks and not the result of other encoding and retrieval strategies. With an intentional procedure, participants are aware that their memory will be assessed and therefore deliberately use any encoding and/retrieval strategies they have at their disposal. Dew and Giovanello (2010) sought to understand and investigate the mechanisms which give rise to the associative memory impairment reported in older adults. Two explanations were discussed in their paper, the first of which concerned an age-related deficit in the binding of separate units of a to-be-remembered episode (Lyle, Bloise, Naveh-Benjamin & Johnson, 2006; Ryan, Leving, Turk-Browne & Hasher, 2007). This view ascribed associative deficits to difficulties in the encoding and retrieval process. An alternative explanation was that specific difficulties in strategic recollection were responsible for the associative deficit (Naveh-Benjamin, Shing, Kilb, Werkle-Bergner & Lindenberger, 2009). This perspective argued that when tests are less reliant upon consciously controlled retrieval, the differences between older and younger adults will be minimized (Light, Prull, LaVoie & Healy, 2000). Test that rely less on controlled retrieval could depend more heavily on familiarity, for example. Evidence indicates a differential age effect is observed between those tasks requiring reinstated associations to be recognised (less dependent on conscious recollection) and those requiring active identification of associative information (Cohn & Moscovitch, 2007). Dew and Giovanello (2010) examined implicit memory for new associations in an attempt to find out which explanation was more appropriate. Implicit memory 'refers to non-conscious, unintentional influences of memory and is measured through priming, which is when performance is facilitated for repeated relative to new stimuli' (Dew & Giovanello, 2010, p.911). If a generalized decline in associative processes was responsible for declines in older adults' episodic memory, then difficulties in associative priming would have been predicted. However, if impairments in the strategic recollection of associative information were responsible, then age differences in associative priming would not have been predicted. Dew and Giovanello (2010) used a paradigm which assessed conceptual associative priming, where older and younger adults were required to make speeded judgements concerning the relationship between objects which were previously unrelated. In the first experiment, participants were instructed to judge whether two objects when put together side by side, were smaller than another object (in this case, a desk drawer). The objects were basic drawings which were familiar such as a shoe, a sofa and so on, and appeared side by side on the computer screen. Participants had to indicate whether the two objects could fit next to each other in a desk drawer of certain dimensions (1' x 2' in this case) by pressing Y or N on the keyboard. For reference an actual desk drawer was provided for participants and emphasis was placed on providing a judgement which was based on the typical size of the objects in the real word, as they were not drawn to scale. After the encoding task, participants were presented with a distractor task which involved solving a series of word anagrams for 5 minutes. Following this, they were subjected to the test which was a speeded version of the same task and involved the presentation of intact, recombined and new object pairs. Participants were instructed to complete the task as quickly and as accurately as they could. Priming would have been evident if correct judgements for objects studied previously were made faster than for objects which were new. Findings revealed that the interaction between age and associative priming was non-significant, indicating that both older and younger adults exhibited equal levels of associative priming. Results therefore suggest that older adults can indeed show evidence of priming for new associations, and so argues against an overall deficit in associative processes. As expected, priming was greater for intact pairs in comparison to recombined pairs, adding strength to the notion that the more environmental support that is provided (as demonstrated by the reinstatement of context), the greater the gains in memory performance.

However, it is not clear whether a general deficit in associative processes is responsible for episodic memory decline in the elderly from using this implicit task. It is possible that rather than relying on and using relational processing to make the speeded classification judgements, participants instead used an item-specific strategy by focusing on objects one at a time to see whether they would fit in the referent object. According to Dew and Giovanello (2010), such a strategy would have been especially challenging 'on trials in which a nominally pair-wise response could be made simply on the basis of the first item' (p. 915). Based on this interpretation, some of the priming observed could have in fact been guided by item-specific rather than relational (associative) processing. Therefore, a further experiment was conducted, where a different task was used in the hopes of preventing participants engaging in item-specific processing. In Experiment 2 participants engaged in a size classification task where both objects had to be processed and considered. Older and younger adults were presented with two objects, and the task was to decide which of them would be more likely to be found inside a house. Object pairs were constructed with the constraint that a consistent, but not entirely obvious, judgement would be made on all trials. This guaranteed that both objects must have been contemplated, and hence relationally processed, in order to make a correct judgement. Like the previous experiment, the test involved the same task, with some object pairs being intact, some being rearranged and some being completely new, and participants having to indicate their judgements as quickly and as accurately as possible. In addition, an explicit associative recognition test was administered; if a significant age difference was revealed in the explicit task but not in the priming task, then this would provide 'more direct support for the hypothesis of spared conceptual implicit associative retrieval processes coupled with impaired explicit retrieval associative processes in aging' (Dew & Giovanello, 2010, p.915).

As with Experiment 1, associative priming did not differ as a function of age, demonstrating that older and younger adults showed similar levels of associative priming. Regarding the explicit test, no age differences were noted in item recognition accuracy, however, the younger adults benefitted more than the older adults in associative recognition accuracy. Taken together, findings from both experiments suggest that 'the disproportionate deficit in associative relative to item recognition following incidental encoding suggests a critical role of impaired strategic recollection of associative information (Dew & Giovanello, 2010, p.918). Therefore it appears that declines in episodic memory performance in older adults could be explained by difficulties in the recollection of associative information. In other words, older adults are capable of incidentally encoding new associations but they have a problem retrieving said information. Therefore, there is some disagreement based on this work as to whether both encoding and retrieval of associative information decline with age or whether it is mainly retrieval.

Overall then, the literature on the ADH suggests that difficulties in the recollection of associative information plays a significant role in the episodic memory decline of the elderly, and that this decline can be reduced by increasing environmental support, and through tasks which allow the older adults to rely on prior knowledge and schematic support. As mentioned in the beginning, the current thesis revolves around an empirical phenomenon that appears to challenge this hypothesis. In particular, it concerns integrative word pairs. Although said pairs lack of pre-existing associations, they nevertheless surprisingly reduce the age-related deficit of the elderly. One of the starting points of the work reported within the thesis was a study that examined age-related differences in associative memory for unrelated as well as for integrative pairs, and how their integrative property could help to reduce the associative deficit typically depicted by the elderly. The next section introduces this work.

1.5 Integrative word pairs

Integrative pairs are combinations of individual noun concepts which refer concisely to an otherwise complex concept (Estes & Jones, 2009). For example, ‘hockey stick’ is a concise reference to the concept ‘a stick used for playing hockey’. Estes and Jones (2009) suggest that for a word pair to be considered as integrative, it must involve sub-classification of some sort. For example, the word pair ‘silver bracelet’ can be considered as an integrative pair as the word ‘silver’ modifies and provides sub-classification of the head noun ’bracelet’ - the bracelet is not just made of any material, but of silver metal. On the other hand, consider the pair ‘salt pepper’. Although this pair is associative, with the word ‘pepper’ being likely to come to mind when exposed to the word ‘salt’, it is not integrative as sub-classification is not involved (salt is not a type of pepper).

Badham, Estes and Maylor (2012) examined the influence of semantic and integrative relations between word pairs on memory recall on older and younger adults. The main aims were to investigate whether integrative relations between words could facilitate memory performance to a level similar to that evoked by semantic relations and whether integrative relations could possibly reduce the associative deficit reliably observed in the older population. The semantic and integrative relations used in the study differed with regards to pre-existing relations; semantic pairs were associated with long term knowledge concerning shared semantic qualities whereas the integrative pairs were considered to be ‘semantically dissimilar, unassociated, and unfamiliar as a phrase’ (Badham et al., 2012, p.5). For example, ‘horse doctor’ can be understood with relative ease even though the two words are dissimilar and do not co-occur together frequently in language. As Badham et al. (2012) pointed out, integrative pairs:

> ‘lack pre-existing relations: They are from different semantic categories, they share few features (if any), they are rarely spoken or written together, and they rarely occur together in a free association task’ (p. 5).

This quality enabled Badham et al. (2012) to investigate the influence of integrative words with minimal pre-existing relations between them (similar to the unrelated pairs) but which could be encoded together relatively easily (similar to the semantic pairs).If age deficits were not found to be alleviated by word pairs consisting of an integrative quality but were reduced with semantically related pairs, then this would suggest that pre-existing knowledge regarding relations between words brought on by the semantic pairs are more important than integratability to the associative memory performance of older adults. If, however, integrative characteristics were found to alleviate age deficits as well as semantic characteristics, this would imply that prior semantic knowledge about word relations is not essential to associative memory performance in the elderly, and that pairs which can be easily integrated together can improve older adults’ associative memory. Both older and younger adults were presented three lists, each containing 15 integrative, 15 semantic, and 15 unrelated cue-target pairs. After the presentation of each list, a brief distractor task was incorporated, followed by a cued recall memory procedure whereby the cue (left word) was presented, with participants having to verbally recall its corresponding partner (right word). As expected, the typical age effect was replicated with the younger adults recalling significantly more than the older adults. The type of list also had an effect, with the unrelated pairs leading to lower memory performance than the integrative and semantic pairs. Moreover, list type interacted with age (see Figure 1.1 below). On one hand, the unrelated condition resulted in the biggest age difference, with younger adults outperforming the older adults. On the other hand, older adults' performance improved more so than the younger adults from the unrelated pairs to the integrative and semantic ones. The large age-related deficit for the unrelated pairs is not surprising given older adults' associative deficit leading to difficulty in forming new associations. The unrelated pairs are devoid of pre-existing association and consequently older adults cannot rely upon prior knowledge to guide them in the encoding and/or retrieval of such pairs. Additional tests revealed that no age by condition interaction was present between integrative and semantic conditions, suggesting that both age groups showed similar differences in their performance from the integrative to the semantic pairs. However, the age by condition interaction was apparent between integrative and unrelated conditions, and between semantic and unrelated conditions, indicating older adults' ability to benefit more than the younger adults from the integration and semantic relatedness between the word pairs. A graph of the results is displayed on the following page.

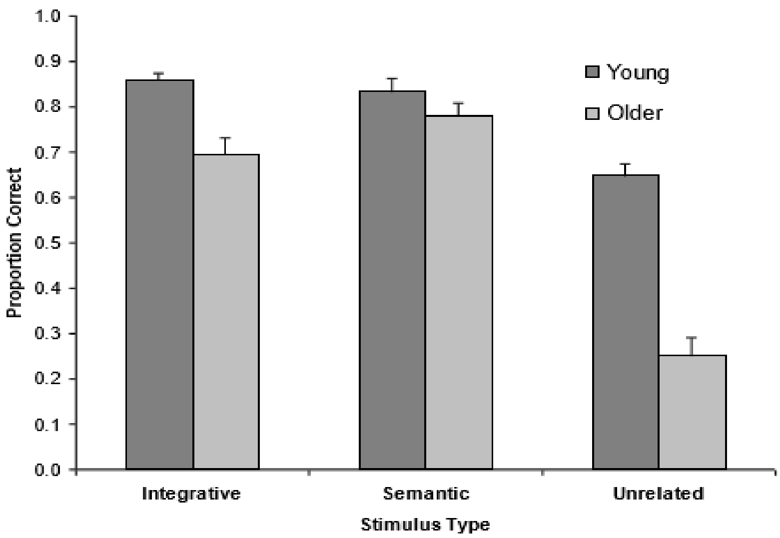

Fig 1.1 Mean proportion of integrative, semantic and unrelated targets recalled across older and younger adults. Error bars represent means to ±1 standard error (reproduced from Badham et al., 2012).

In conclusion, integrative relations were found to facilitate the memory performance of older adults, to the extent that there was no significant age difference in recall for the integrative pairs. The fact that the integrative pairs used in Badham et al.'s (2012) study were unassociated and dissimilar was thought to indicate that 'their attenuation of the age related memory deficit cannot be directly attributed to pre-existing relations' (Badham et al., 2012, p.20). This challenges the views of the ADH which would have predicted that the lack of pre-established associations of the integrative pairs should have resulted in the emergence of older adults' associative deficit, as they would not have been able to rely on pre-existing word relations to facilitate memory performance.

The starting point for this thesis was that, closer inspection of the integrative word pairs used by Badham et al. (2012) revealed that over half of the integrative pairs (25 out of 45) already had pre-existing relations as assessed by the University of South Florida Free Association Norms (Nelson, McEvoy & Schreiber, 1998). This suggests that the integrative advantage demonstrated by the older adults may in fact by due to pre-existing knowledge regarding word relations after all, and implies that the older adults still may exhibit an associative deficit when presented with integrative word pairs which are devoid of any such associations.

The first experiment reported here concerned this issue and attempted to find out whether pre-existing associations could possibly explain the integrative advantage observed in older adults in the Badham et al. (2012) study. In summary then, research has indicated that integrative relations can facilitate memory performance, especially for older adults. However, it is unclear whether this facilitation is the result of pre-established associations existing within the integrative pairs.

Chapter Two: Associative strength, item-specific and relational processing in the context of integrative pairs

2.1 Abstract

The series of experiments presented herein aimed to compare young and old adults' performance in paired-associate tasks while examining the effect of integrative relations on recall. Integrative relations arise when two words form a coherent phrase, e.g. 'horse doctor'. In Experiment 1, young and older adults studied integrative associative, integrative non-associative and unrelated word pairs. At test, the first word of each pair was provided as a cue. Recall was superior with integrative associative relative to integrative non-associative pairs, suggesting that pre-established associations are beneficial to associative memory of both age groups. Pair type interacted with age indicating recall for unrelated pairs was considerably worse than in the other conditions and exhibited the largest age-related difference compared to the other two pair types. Findings suggest older adults benefit more than younger adults from integrative relationships. Experiment 2 investigated item-specific and relational processing on cued-recall of integrative and unrelated pairs for both age groups. As integrative pairs were thought to encourage relational processing, item-specific processing of integrative pairs was predicted to remove their advantage resulting in a performance similar to that of unrelated pairs. The item-specific task involved rating each word for pleasantness and the relational task involved constructing a sentence using both words in each pair. The largest age-related difference was obtained in recall of the unrelated pairs in the item-specific task; however, integrative pairs were still recalled significantly better than unrelated ones. One explanation was that simultaneous presentation of integrative pairs resulted in uncontrollable relational processing, even when participants were instructed to focus on item-specific properties. Experiments 3a and 3b manipulated presentation format of the pairs so the words in each pair either appeared simultaneously, or one at a time, as well as implementing a more elaborative item-specific task which required participants to construct a sentence involving one

member of each pair. As anticipated, increased elaboration of the item-specific task, as well as serial presentation, was found to remove the integrative advantage in the item-specific task.

2.2 Introduction

Normal, healthy aging is typically associated with various impairments in memory functioning, with the size of these age-related deficits depending upon the type of memory task used to assess performance (Naveh-Benjamin, 2000; Zacks, Hasher & Li, 2000). Indirect memory tests, which assess the retention of information without direct reference to the source of the information (e.g. priming studies), show little or no age-related decrement. For example, younger and older adults show similar priming effects on word-stem completion (Geraci & Barnhardt, 2010) and word-fragment completion tasks (Ikier & Hasher, 2006) where memory for presented information is measured without explicit reference to prior learning episodes (Ward, Berry, & Shanks, 2013). Age-related differences obtained in direct memory tests have also been shown to depend upon the type of task, with serial and free recall producing clear differences between older and younger adults (Maylor & Henson, 2000) and recognition memory yielding the smallest deficits (Craik, 1977).

Explanations for this pattern of age-related performance have recently insisted on the requirement to form new associations, with memory deficits being reliably obtained in older adults when paradigms entail such associations to be formed (Craik & McDowd, 1987; Naveh-Benjamin, Craik & Ben-Shaul, 2002). For example, Rabinowitz (1986) presented lists of related (string-guitar) and unrelated (dart-telephone) word pairs to both older and younger adults. In a subsequent cued-recall test, it was found that the age-related deficit was larger for unrelated than for related pairs. Performance was thought to reflect the degree of integration between the cue studied at encoding and the target item, and the greater age-related decrement for unrelated relative to related pairs was attributed to the need to create novel relationships between items.

Chalfonte and Johnson (1996) tested older and younger adults' recognition memory for item, feature and the association between feature and item information. Item memory (remembering which items were presented or which colours were presented) was equivalent for both older and younger adults. However, when tested on item plus feature information (for example, remembering that an item was presented in a green colour), an age related deficit was found, despite preserved memory for item and colour information when tested separately. These findings suggest that the binding of information underlies at least some of the memory deficits shown by older adults (Bireta et al., 2008; Chalfonte & Johnson, 1996; Mitchell, Johnson, Raye, Mather & D'Eposito, 2000; Naveh-Benjamin 2000).

In light of these and other findings, Naveh-Benjamin (2000) proposed the associative deficit hypothesis (ADH) to explain the difficulties older adults have in recalling associative information. The ADH suggests that older people struggle when creating and retrieving links between units of information; according to this view, they find it difficult to bind different aspects of an episode into a cohesive unit, and as a result, their memory suffers when asked to recall or recognize this information. Naveh-Benjamin (2000) tested the main predictions of the ADH. He presented related or unrelated word pairs, after which participants were tested with three different memory tasks; in the free recall task, participants were required to recall as many of the target (second) words as they could; cued recall involved the recall of the second item belonging in the pair when presented with the first word as a cue; finally the recognition task required participants to recognize the correct pairs. A counterintuitive prediction was made based on the ADH: free recall of the targets was expected to be somewhat less age sensitive than cued recall, because it involved operations not directly related to the retrieval of specific associations (e.g. initiation of a memory search and generation of cues). In other words, what was required in the free recall test is the recall of the items without reference to pairings, rather than the specific target associated to the cue which would be necessary in the cued recall test. This is precisely what was found, with the largest age-related deficit being obtained in the cued recall of unrelated pairs. Such a finding is in line with the ADH, as the cued recall of unrelated pairs involved direct encoding and retrieval of specific, and novel, associations. In contrast, age differences more or less disappeared when testing involved the cued recall of pairs which were related (i.e. had associations based on prior knowledge). As cued recall of the related pairs relied less on the creation of new associations, this implies that older adults' difficulty in binding units of information together is limited to new associations.

Since then, a number of studies have reported an age-related associative deficit (Bender & Raz, 2012; Cooper & Odegard, 2012; Hartman & Warren, 2005; Overman & Becker 2009). However, a recent study conducted by Badham, Estes and Maylor (2012) suggested that older adults are just as able as younger adults to form new associations under some circumstances. Badham et al. (2012) compared the effects of semantic and integrative relations between word pairs on memory. According to Estes and Jones (2009), integrative relations are those existing between two words which, when put together, refer concisely to a single compound, and which form a coherent phrase i.e. 'ocean fish'. Integration is thought to involve a process whereby the first word of the pair modifies the meaning of the second word. The modifier (first word) entails a sub classification of the head noun (second word), so travel book is a specific type of book, and horse doctor is a specific type of doctor, different from other and more general types of doctors (e.g. Glucksberg & Estes, 2000). Integration can occur among compounds which are associated, such as 'spider web', 'bird nest', 'coffee shop', and such pairs tend to co-occur together quite frequently. Words can also be integrated together in compounds which are not previously or rarely associated e.g., 'monkey foot' can be easily understood despite the fact that monkey and foot are dissimilar and do not co-occur frequently in the English language. Thus integrative pairs can differ in terms of their level of association and co-occurrence; associated integrative pairs tend to co-occur more frequently than less associated integrative pairs. Badham et al. (2012) chose to study only those integrative pairs which were unassociated in order to rule out the possibility of association and/or familiarity having an influence on recall. The integrative word pairs used by Badham et al. (2012) were thought to lack pre-existing associations as they 'are from different semantic categories, they share few features (if any), they are rarely spoken or written together, and they rarely occur together in a free association task' (p. 5).

Jones, Estes and Marsh (2008) demonstrated that integrative relations can aid memory. Younger adults were presented with word pairs which were more easily integratable in one order e.g. 'horse doctor' than in the reverse order e.g. 'doctor horse'. They were subsequently given a surprise recognition memory test of the individual words. The results showed that words were recognized better when they had been studied in their more easily integrated order i.e. 'horse doctor' than when they had been studied in their less integratable order i.e. 'doctor horse'. This illustrates the beneficial effects of integrative relations, and how they can facilitate item memory.

In the experiment conducted by Badham et al. (2012), a cued recall task was employed, involving the presentation of three pair types: integrative ('travel book'), semantically related ('article book') and unrelated ('lapel book'). Stimuli were obtained from Estes and Jones (2009) and were based on pre-testing – participants rated the extent to which word pairs could be linked together to form a coherent phrase on an integratability scale from 1 (not linked) to 7 (tightly linked). They also rated featural similarity of word pairs on a semantic scale from 1 (not similar) to 7 (highly similar). The chosen integrative stimuli were high on integratability but low on featural similarity, e.g. 'travel book', 'birthday candle', 'race car' and the chosen semantic stimuli were low on integratability but high on featural similarity e.g. 'fox dog', 'lawn garden', 'liver heart'.

From these stimuli, a set of targets were generated, with each target having a corresponding integrative, semantic and unrelated cue word. For example, the target word 'book' had the integrative cue 'travel', the semantic cue 'article', and the unrelated cue 'lapel'. The experiment involved presenting participants with word pairs from each of these groups, and later asking them to recall the target when provided with the corresponding cue word. Altogether, 3 lists were shown, each consisting entirely of integrative, semantic or unrelated cue-target pairs [with targets not repeated across conditions]. As expected, older adults recalled fewer targets than their younger counterparts. Performance was also substantially lower in the unrelated condition than in the integrative and semantic conditions [there was no difference between these latter two conditions]. Importantly, older adults showed a greater benefit than younger adults when unrelated pairs were replaced by integrative and semantic word pairs. In other words, the age-related memory deficit evident in the unrelated conditions was significantly reduced for word-pairs with a semantic or integrative relationship. Since these integrative word pairs were said to be semantically dissimilar and unassociated, their impact on the age-related memory deficit could not easily be attributed to pre-existing associations. The findings hence suggested that older adults are able to form new associations between the items from integrative pairs, as well as being able to successfully retrieve the associative information during cued recall; in effect, in this study, older adults did this as well as younger adults with the integrative pairs as no age-related deficit was statistically significant for these pairs . Such findings are difficult to predict based on the ADH, and suggest older adults, under some conditions at least, can form new associations as well as younger adults.

However, closer inspection of the integrative word pairs presented using the University of South Florida Free Association Norms (Nelson, McEvoy & Schreiber, 1998) indicated that over half of the integrative word pairs (25/45) actually did have pre-established associations. Therefore, the smaller age-related deficit found with integrative pairs could be due to the fact that a significant number of the word pairs already had pre-existing associations, casting doubt on the novel finding reported in this paper.

2.3 Experiment 1

The present experiment separated the original integrative word pairs used in Badham et al.'s (2012) study into two separate lists; integrative associative and integrative non-associative pairs. It is expected that a difference in recall will be obtained for these two list types, with integrative associative pairs being recalled at a higher rate than integrative non-associative pairs for both older and younger adults. This is because the pre-established associations between the items aid the encoding and retrieval process – item pairs will be remembered better if they have been encountered before, and if an association between them already exists. Furthermore, a greater age-related deficit is predicted for integrative non-associative word pairs than integrative associative pairs because of older adults' difficulty forming new associations. If previously established associations are necessary for the successful memory performance of older adults as the ADH predicts, then recall of the integrative associative pairs will exceed that of the integrative non associative and unrelated pairs, relative to the younger adults. Finally, the cued recall of unrelated word pairs will also be investigated, and a strong view from the ADH would predict that integrative non-associative pairs will produce performance that is the same or closer to the unrelated pairs than with the integrative associative pairs for the older adults, due to their difficulties creating and retrieving new associations.

2.3.1 Method

2.3.1.1 Participants

Twenty young adults (14 female) aged 18-35 and twenty healthy older adults (15 female) aged 65-87 years took part in the experiment. Young participants consisted mainly of undergraduates at City, University of London who participated in exchange for course credit/money. The others were enlisted via advertisements placed on websites and through a university designed system which contained details of experiments. Older participants were recruited by advertisements placed in the local newspaper and through word of mouth; and were reimbursed for their travel expenses.

Both young and older participants completed the Wechsler Abbreviated Scale of Intelligence (Wechsler, 1999) as a brief measure of intelligence. An independent t-test was conducted on the IQ data for both young and older participants and revealed that IQ did not vary significantly between the two age groups ($t(38) = .319$, $p = .752$). In addition, the Mini Mental State Examination 2

(Folstein & Folstein, 2012) was administered to older adults as a means of screening for cognitive impairment. Scores of 27 and above (out of a maximum of 30) for each participant would rule out the possibility that poor recall on the memory test was a consequence of impaired cognitive ability, and would ensure that the elderly participants were functioning healthily (Table 2.1).. Older adults also completed the Geriatric Depression Scale to measure of their depression levels as depression has been linked to poor memory (Hubbard, Hutchison, Turner, Montroy, Bowles & Rypma, 2016). Finally, for all participants, information was collected concerning their occupation and education level.

Table 2.1 The mean age and scores from the WAIS, MMSE-2, and the GDS for younger and older adults. Standard deviations are indicated in parentheses.

	Age	WAIS	MMSE-2	GDS
Younger adults	20.2 (2.8)	108.3 (7.8)	n/a	n/a
Older adults	74.1 (3.2)	108.9 (7.2)	28.4 (0.9)	5.4 (1.3)

2.3.1.2 Materials

Some integrative word pairs were taken from Badham et al. (2012). The stimuli were originally selected based on pretesting results from Estes and Jones (2009): participants rated the extent to which word pairs could be linked together to form a coherent phrase on an integratability scale from 1 (not linked) to 7 (tightly linked). The original list of 45 integrative pairs was separated into 2 groups, with 25 pairs in the integrative associative condition and 20 pairs in the integrative non-associative condition. Integrative pairs were considered to be associative if the second member of the pair (target) appeared as a response to the first member of the pair (cue) using the University of South Florida Free Association Norms. Pairs were thought to be unassociated if the target didn't appear in response to the cue. Additional integrative pairs were constructed to make the total of each list 45. In a similar procedure to that adopted by Estes and Jones (2009) and described previously, 20 participants at City, University of London rated the extent to which the pairs could be linked together to produce a coherent phrase. In addition, participants also rated the extent to which the words could be associated to one another on a scale from 1 (not associated) to 7 (highly associated). The chosen integrative associative stimuli received high ratings for integratability (M = 5.8, SD = 0.83), as well as associativeness (M = 5.6, SD = 0.75), whilst the chosen integrative non-associative stimuli received high ratings for integratability (M = 5.7, SD = 0.86), but low ratings for associativeness (M = 2.4, SD = 0.82).

Another measure of association was obtained using the University of South Florida (USF) Free Association Norms (Nelson, McEvoy & Schreiber, 1998). Word pairs were considered to be associated to each other if the second item of the pair appeared as a response to the cue item (first word) so all the second items in the integrative associative condition appeared as responses to the first word. In cases where the second word did not appear as a response, it was assumed that there was no association to the first word, so all items in the integrative non-associative and unrelated conditions had no association to each other in accordance with the USF Free Association Norms.

The MRC Psycholinguistic Database (Wilson, 1988) ensured that there were no significant differences in word characteristics such as imagery, familiarity and concreteness between the integrative associative, integrative non-associative and unrelated word pairs (see Appendix). To determine the optimal presentation rate of the memory pairs for both older and younger adults, a pilot study was conducted, involving 15 participants. A rate of 5 seconds per pair was chosen for the young adults to prevent ceiling effects, and 10 seconds per pair for the older adults to prevent floor effects. These presentation rates were the same as those used in Naveh-Benjamin’s (2000) Experiment 4.

2.3.1.3 Procedure

The stimuli were organized into 3 sets, each of which consisted solely of one item type: integrative associative, integrative non-associative or unrelated pairs. Each set hence contained 15 pairs as well as 2 additional pairs that were used at the start and one at the end to act as buffers. These additional pairs had the same type of relationship to the other pairs in the block – either integrative associative, integrative non associative or unrelated. Therefore, a total of 17 pairs were presented to participants for each memory test, with participants completing a separate memory test for each of the 3 pair types. Word pairs were displayed in black in the centre of a computer screen with a white background, using the software Visual Basic. Words were presented in lower case with an Arial font size of 20.

Participants were presented with a practice trial before the main memory test. The practice trial involved the presentation of 6 word pairs sequentially (2 of each relationship type, integrative associative, integrative non-associative and unrelated), at the same rate as what was used for the experimental lists. They were instructed to memorize the word pairs for an upcoming memory test, in which they would be required to verbally recall the right member of each pair when presented with the left word as a cue.

As in the Badham et al. (2012) study, once the last pair had been presented, there was a 1 minute delay during which participants were instructed to count backwards in threes from 200. Afterwards, a single cue word (always the left word of each pair) was shown on the computer screen. Participants verbally recalled the corresponding target word for each cue word, whilst the experimenter noted down their responses. After their response had been made, participants pressed a button to bring up the next cue word on the screen. The cue words were presented randomly for each participant.

The main experimental procedure involved attempting the recall of three lists, one for each type of pair relationship. Participants were told that they could rest between the conditions if they desired. The order of the conditions was counterbalanced; every possible order of the 3 list conditions (6 combinations altogether) was used, rotated across participants. A total of 45 target words were used as the stimuli for this experiment, each paired with a corresponding integrative associative, integrative non-associative and an unrelated cue word. This resulted in 3 sets of 45 cue-target pairs, which all had the same 45 target words e.g. the target word ‘candle’ could be presented in one of three combination: integrative non-associative – ‘dinner candle’, integrative associative – ‘birthday candle’, and unrelated – ‘pillow candle’. The stimuli were organized so that each participant only saw each target once, meaning that they were all recalling the same 45 target words, but not from the same cues. For each participant, target words were matched to 15 integrative non-associative, 15 integrative associative, and 15 unrelated cue words, with the constraint target words only appeared once (15 pairs per list x 3 lists = 45 targets). The combination of 15 cues selected for each pair type varied across participants so that no participant was presented with the same 15 cue-target pairs as another one. During both presentation and cued recall, individual stimuli were presented in a randomized order within each experimental block.

2.3.2 Results

2.3.2.1 Original Badham et al. (2012) stimuli

As a preliminary analysis, the performance for the original Badham et al. (2012) stimuli was examined. Recall that the authors used some integrative pairs which were associated according to the USF Free Association Norms and some which weren’t associated, so an analysis was conducted with the hopes of achieving a difference in recall between the integrative associative and the integrative non-associative pairs, with memory anticipated to be superior for the integrative pairs which had pre-existing associations. For each participant, the mean proportion of correctly recalled targets was calculated for the pairs originally called upon in the Badham et al. (2012) study; performance for the integrative associative and integrative non associative pairs was considered separately. Table 2.2 presents the means for each group and condition.

Table 2.2. Mean proportion of integrative associative, integrative non-associative and unrelated targets recalled for young and old adults (s.d in brackets).

	Young adults	Old adults
Integrative associated pairs	0.81 (0.09)	0.74 (0.12)
Integrative non-associated pairs	0.71 (0.09)	0.60 (0.17)

A 2 (age: young, old) x 2 (pair type: integrative associative, integrative non associative) repeated measures ANOVA was conducted on the original Badham et al. (2012) stimuli (25 integrative associative pairs and 20 integrative non associative pairs). There was a main effect of age ($F (1, 28) = 5.146$, $MSE = 0.118$, $p = .031$) and pair type ($F (1, 28) = 38.749$, $MSE = 0.211$, $p<.001$), with the integrative associative pairs being recalled at a higher rate than the integrative non associative pairs. However, the interaction between age and pair type did not reach significance ($F (1, 28) = 0.704$, $MSE = 0.004$, $p = .408$). The findings suggest that there were integrative pairs that benefited from prior association (as defined by the USF norms). As the interaction did not approach significance, the suggestion is that for these stimuli at least, going from non-associative to associative integratable pairs has the same beneficial impact on younger and older adults.

2.3.2.2 Main analysis

In order to ascertain whether integrative associative, integrative non associative and unrelated pairs were remembered differently by young and old adults, a 2 (age: young, older) X 3 (pair type: integrative associative, integrative non associative and unrelated pairs) repeated measures ANOVA was conducted on the cued recall data. Figure 2.1 summarises mean performance for younger and older adults.

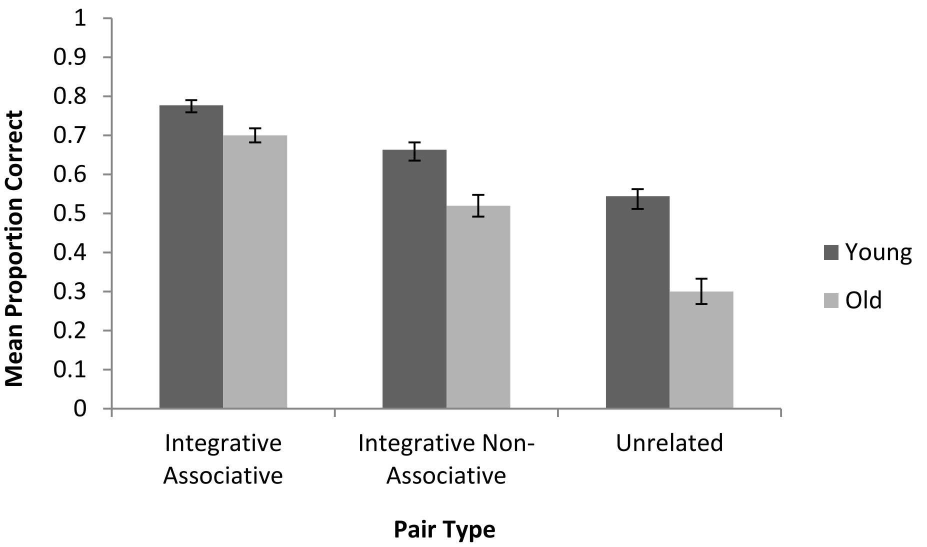

Fig 2.1 Proportion of integrative associative, integrative non-associative and unrelated targets correctly recalled across older and younger adults. Error bars represent means to ±1 standard error.

Figure 2.1 suggests that across all pair types, the younger adults recalled more items correctly than the older adults. Also, integrative associative pairs seemed to be recalled the best and unrelated pairs the worst. In addition, the age difference appeared to be the largest with the unrelated pairs, and the smallest with the integrative associative pairs. The ANOVA confirmed these observations: there was a main effect of age ($F(1, 38) = 33.684$, $MSE = 0.719$, $p<.001$) with more items being correctly recalled by the younger adults in comparison to the older adults, and a main effect of pair type ($F(2, 76) = 230.081$, $MSE = 1.00$, $p<.001$) with the integrative associative pairs producing greater recall overall. The interaction between age and pair type was also significant ($F(2, 76) = 16.259$, $MSE = 0.071$, $p<.001$). This appeared to be due to the larger age difference between young and older participants for the unrelated word pairs.

In order to determine the source of the interaction, two separate ANOVAs were conducted, each examining age and two of the conditions at a time. The first 2 (age: young vs old) x 2 (pair type:

integrative associative vs integrative non-associative) ANOVA indicated a main effect of pair type ($F (1, 38) = 153.353$, $MSE = .431$, $p<.001$) a main effect of age ($F (1, 38) = 18.003$, $MSE = .243$, $p<.001$), as well as a significant interaction between pair type and age ($F (1, 38) = 7.873$, $MSE = .022$, $p = .008$). From looking at Figure 2.1, we can see that the older adults showed a greater increase in performance from the non-associative to the associative pairs than the younger adults (increase of 0.18 for the older adults vs increase of 0.12 for the younger adults). The second 2 (age: young vs old) x 2 (condition: integrative non-associative vs unrelated) ANOVA indicated a main effect of pair type ($F (1, 38) = 123.320$, $MSE = .573$, $p<.001$), an age effect ($F (1, 38) = 36.905$, $MSE = .751$, $p<.001$), as well as a significant pair type x age interaction ($F (1, 38) = 10.870$, $MSE = .051$, $p = .002$). Figure 2.1 indicates that the older adults benefitted more than the younger ones from the integration between the pairs, as the older adults' performance rose by 0.22 from the unrelated pairs to the integrative non-associative ones, whilst the younger adults' performance increased by only 0.12 from the unrelated pairs to the integrative non-associative ones. Therefore, in both instances, the elderly clearly benefitted more than the young from the integration of the word pairs, as well as the association between them.

2.3.2.3 Item-based analysis

As the degree of association, based on the University of South Florida norms, of the integrative non-associative and the unrelated pairs was equated, we were expecting the integrative non-associative pairs to behave like the unrelated ones, due to lack of pre-existing associations. However, as the main analysis shows, the integrative non-associative pairs were recalled significantly better than the unrelated ones across both age groups, suggesting that some other component may be at play and may be able to explain the superiority of the integrative non-associative pairs over the unrelated ones. One possibility was that the integrative non-associative pairs co-occurred together more frequently than the unrelated ones. Local co-occurrence can be defined as 'the frequency with which two words occur directly adjacent to one another in a large text corpus' (Estes & Jones, 2009, p 121). It is understood that items which co-occur together more frequently are more likely to be associated to each other than items which co-occur less frequently, with higher values indicating a stronger association (Wisniewski & Murphy, 2005). Following Wisniewski and Murphy (2005), a measure of local co-occurrence for each pair was obtained using Google Hits, which states the number of occurrences of the chosen noun compound. Each pair was typed into the search box with speech marks around the pair (‘’), and the number of hits was taken as an estimate of co-occurrence. A significant difference was found between the pair types, in that integrative associative pairs had higher co-occurrence values than integrative non associative pairs, which in turn had higher co-occurrence values than unrelated pairs. Therefore, it is possible that the integrative non associative pairs (taken to be non –associative according to the USF Free Association Norms as the target did not appear as a response to the cue) were more associated than assumed, and that the difference between integrative non associative and unrelated pairs could be explained in terms of co-occurrence, rather than integration. The table below shows the average Google Hits for each pair type and clearly indicates that the integrative associative pairs co-occurred together the most, with the integrative non associative pairs co-occurring less frequently, and the unrelated pairs occurring together the least.

Table 2.3 The average Google hits for each pair type.

Pair type	Average Google Hits
Integrative Associative	10,280,207
Integrative Non-Associative	1,918,654
Unrelated	21,148

Log Google hits were computed as the Google hit values were not normally distributed. To rule out the possibility that the integrative non associative pairs were more associated than previously thought, an item-based analysis was performed; in this analysis the item pairs were the observations and the mean performance for each pair in both the older and younger adult groups was computed and used as the measurements. A 2 (proportion correct: young, old) x 3 (pair type: integrative associative, integrative non associative, unrelated) repeated measures ANCOVA was performed with log Google hits as a covariate to see whether the stimuli produced different performance levels for the age groups when co-occurrence was controlled for. The figure below shows the mean proportion of targets correctly recalled for both age groups with log Google hits as the covariate.

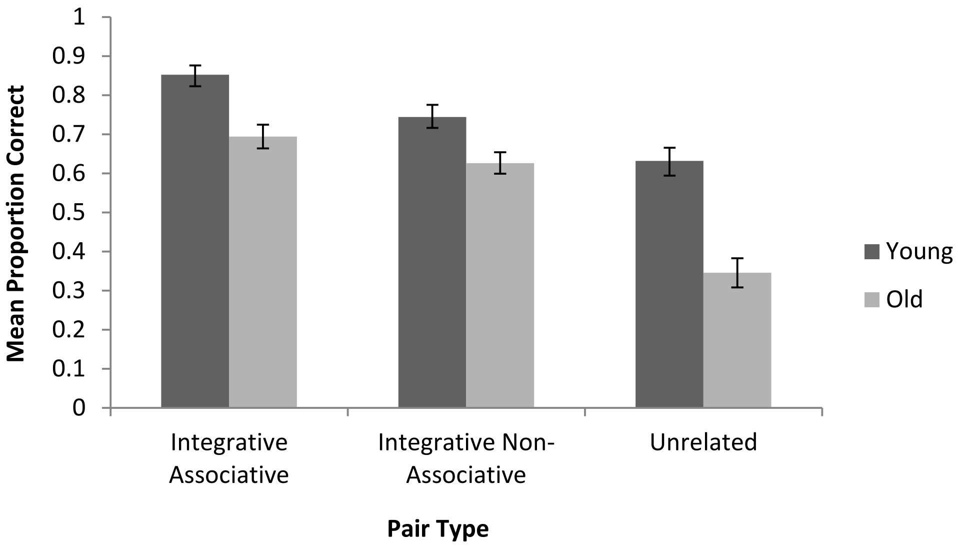

Fig 2.2 Mean proportion of integrative associative, integrative non-associative and unrelated targets recalled across older and younger adults with log Google hits as the covariate. Error bars represent means to ±1 standard error.

A main effect of age was found (F (1, 131) = 91.177, MSE = 23660.116, p<.001), as was a main effect of pair type (F (1, 131) = 8.343, MSE = 2503.189, p<.001), as well as an interaction between age and pair type (F (2, 131) = 6.547, MSE = 1698.830, p = .002). In order to determine the source of the interaction, two separate ANCOVAs were conducted, each examining age with two of the pair types at a time, with log Google hits as the covariate. The first 2 (age: young vs old) x 2 (pair type: integrative associative vs integrative non-associative) ANCOVA indicated a main effect of age (F (1, 87) = 17.130, MSE = 4316.689, p<.001), but no main effect of pair type (F (1, 87) = 2.816, MSE = 652.733, p = .097). In addition, the age x pair type interaction failed to reach significance (F (1, 87) = .091, MSE = 22.949, p = .764) implying that both older and younger adults showed a similar improvement in performance from the integrative non-associative to the integrative associative pairs. The second 2 (age: young vs old) x 2 (condition: integrative non-associative vs unrelated) ANCOVA showed a main effect of age (F (1, 87) = 53.796, MSE = 14976.721, p<.001), a main effect of pair type (F (1, 87) = 7.384, MSE = 2520.825, p = .008), as well as a significant age x pair type interaction (F (1, 87) = 10.719, MSE = 2984.292, p = .002) with the older adults benefitting more than the younger ones from the integration between the pairs. The means from Figure 2.2 have been reproduced on the following page for clarity.

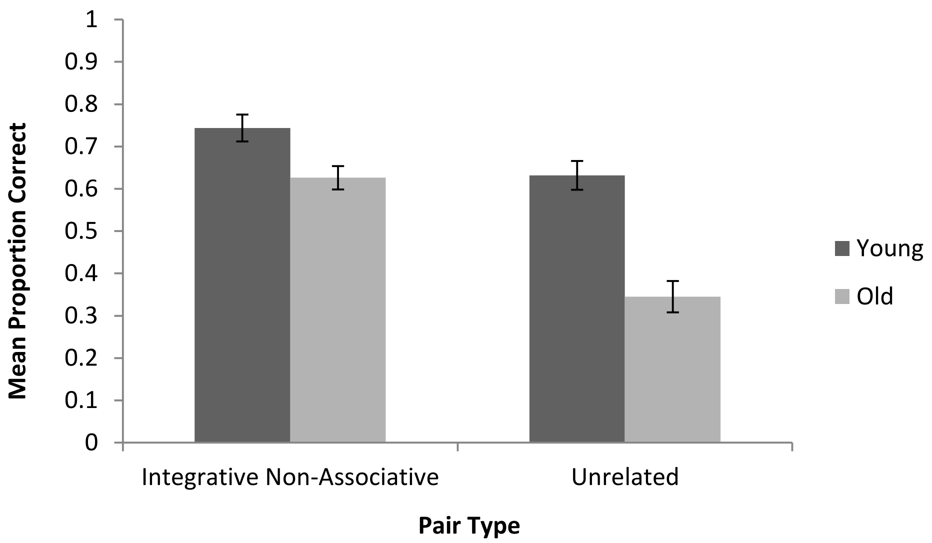

Fig 2.3 The mean proportion of integrative non-associative and unrelated targets recalled across older and younger adults with log Google hits as the covariate. Error bars represent means to ±1 standard error.

The older adults' performance rose by 0.28 from the unrelated pairs to the integrative non-associative ones, whilst the younger adults' performance increased by only 0.11. Therefore, when co-occurrence was controlled for, the elderly clearly continued to benefit more than the young from the integration of the word pairs, as their performance improved significantly more than the younger adults from the transition of the unrelated to the integrative non associative pairs. However, there was no significant interaction with age between the integrative non associative and the integrative associative pairs when co-occurrence was controlled for, suggesting that both age groups equally benefitted from the association provided by the integrative pairs. This is in contrast to the main analysis when co-occurrence was not used as a covariate, which showed an interaction with age between the integrative non associative and the integrative associative pairs, with the older adults' benefitting more from the association existing between the integrative pairs. In summary, co-occurrence could therefore explain the age effect obtained between the integrative associative and the integrative non associative pairs but did not reduce the age-related advantage conferred by integrative non-associative pairs relative to unrelated pairs.

2.3.3 Discussion

The main objective of the present experiment was to see whether pre-established associations existing between some of the integrative pairs could explain older adults' memory advantage for these items relative to unrelated pairs in the original Badham et al. (2012) study. If previously established associations were necessary for the successful memory performance of older adults as the ADH predicts, then recall of the integrative associative pairs should have exceeded that of the integrative non associative and unrelated pairs, relative to the younger adults. Due to the lack of prior associations in the integrative non-associative and the unrelated pairs, the older adults may have struggled when it came to recall as successful cued recall would have relied on the formation of associations between previously unassociated items, which they are known to have difficulty with. In contrast, the older adults would have been able to benefit from the prior associations existing between the integrative associative pairs as this would not have required new associations to be formed. If, however, integratability of word pairs was an important component in facilitating memory performance, then both the integrative associative and the integrative non-associative pairs should have produced better performance, and an age-related benefit, compared to the unrelated pairs.

In line with previous research, Experiment 1 showed an overall memory deficit was exhibited by older adults in comparison to younger adults (Naveh-Benjamin, 2000; Salthouse, 2010). A comparison of Badham et al.'s (2012) original integrative pairs (45 in total) indicated that there was, in fact, a significant difference in level of recall between those integrative pairs already having pre-established associations, and those integrative pairs without such associations, with the latter leading to poorer memory performance. Also, the greatest age-related difference was obtained with the unrelated pairs, presumably because of older adults' difficulty forming new associations.

A difference in performance was obtained between the integrative associative and integrative non associative word pairs across older and younger adults. As both pair types were integratable, the only difference between them was that of association, and not surprisingly, a greater proportion of integrative associative pairs were recalled than the integrative non-associative ones. The pre-established associations existing between the integrative associative items aided the encoding and retrieval process, and so enhanced memory capability. Items were recalled and hence remembered better as they had been encountered before, and as an association between them already existed.

The finding above supports the associative deficit hypothesis, as older adults' performance was most detrimentally affected when they were required to form novel associations between items. These results are in line with Badham et al.'s (2012) findings as performance for both young and older adults was the lowest when presented with the unrelated pairs. If the results from the current experiment were to conclusively support Badham et al.'s (2012) findings, then a difference in recall would not have been expected to have been found between the integrative associative and integrative non associative pairs, but it was - clearly the associations already existing between the integrative pairs enhanced recall, and meant that older adults did not have to form new associations.

Age interacted significantly with pair type, and revealed that the older adults benefitted significantly more than the younger adults from both the association between the pairs (integrative associative vs integrative non-associative) as well as the integration between them (integrative non-associative vs unrelated). In accordance with prior research, the largest age difference was obtained in recall of the unrelated pairs, presumably because of older adults' associative deficit. Past literature has indicated that older adults find it easier to encode associative relations because fewer new associations need to be created in memory (Naveh-Benjamin, 2000), therefore it is not surprising that performance was the highest with the integrative associative pairs; the pre-established associations meant older adults had to rely less on forming new ones.

Apart from associativeness, integratability of stimuli was another factor producing enhanced memory performance demonstrated by young and older adults when presented with integrative pairs relative to unrelated pairs. Integrative relations facilitated word processing among older adults, and reduced the associative deficit. The older adults clearly benefitted more than the younger adults from the integratability of the stimuli as their performance disproportionally rose from the unrelated pairs to the integrative non-associative pairs relative to the younger adults. The integrative non associative word pairs were dissimilar and unassociated according to the University of South Florida Free Association Norms, so their reduction of the age-related memory deficit could not directly be ascribed to pre-existing relations. However, as mentioned previously, the integrative non-associative pairs co-occurred together more frequently than the unrelated pairs, so perhaps this could have offered an explanation as to why the integrative non-associative pairs were recalled significantly better than the unrelated ones. When an ANCOVA was run with co-occurrence as the covariate, a most interesting finding emerged; older adults benefitted more than the younger adults from the use of integrative pairs with no pre-existing association - even when co-occurrence was controlled for, performance was still higher with the integrative non associative than with the unrelated pairs. This suggests that integration, rather than association, may be the source of the reduced associative deficit portrayed by the older adults. One possibility is that integrative pairs encourage relational processing, which could explain why performance was facilitated. To be integrative, a word pair has to make coherent sense, and must involve sub-classification, as well as the ability to *relate* the concepts successfully together. As Estes (2003) says, ‘in order to comprehend two concepts together, one must infer some relation between them’ (p. 913). From this viewpoint, it could be argued that relational processing can explain the integrative advantage. What would happen if relational processing of the integrative pairs were prevented in some way? The aim of the next experiment was to investigate the influence of item-specific and relational processing on the recall of integrative and unrelated word for groups of younger and older adults. A brief review of the literature regarding item-specific and relational processing will be presented first, focusing on the research findings concerning age effects related these two forms of processing.

2.4 Experiment 2

2.4.1 Introduction

Hunt (2000) suggested that item-specific and relational processing may be beneficial for investigating age differences in memory performance. Item-specific processing relates to the distinctiveness of each item in comparison to others, and is typically induced by tasks requiring participants to focus on the distinctive properties of items, such as rating the pleasantness of each item. In other words, the properties unique to individual items in an event are focused upon. According to Hunt and Einstein (1981), item-specific processes 'emphasize[s] the importance of highly specific information representing each of the separate input events' (p.497). Conversely, relational processing involves the detection of relationships among elements of an event, and can be evoked, for example, by sorting tasks where lists are organised into categories. Such a process allows the integration of discrete elements into a whole. In summary, tasks involving item-specific processing typically highlight the distinctive properties of items whilst those involving relational processing focus on shared characteristics and relationships.

The item-specific-relational distinction incorporates two ideas concerning the different forms of encoding processes that can facilitate recall – item elaboration (Craik & Lockhart, 1972) and item organization (Tulving, 1962). Hunt and Einstein (1981) attempted to shed light on these two ideas. The organizational view implies that enhanced memory is the result of a memory trace which includes information considered to be common to a number of distinct events. Therefore, the most appropriate processing mechanism in accordance with this view involves 'the abstraction of relational information shared by the elements or events present at input' (Hunt & Einstein, 1981, p.

497). This organizational approach highlights the necessity and importance of engaging in the relational encoding of information. The elaboration view regards the processing of highly specific information related to each element to be important for optimal memory performance. Elaborative processes serve to relate semantic information brought on from the event to other parts of the person's knowledge base. In this vein, elaboration is thought to increase the distinctiveness of the memory trace – relative to any other elements that are encoded within the same episode (Hunt & Einstein, 1981). Hunt and Einstein (1981) asked whether a distinction could be made between these two types of processing by observing whether performance would be affected by manipulations of item-specific and relational processing, by varying the orienting task and nature of the materials.

They found that the encoding of both item-specific and relational information resulted in higher recall than when only one form of encoding was encouraged. In addition, it was discovered that where the list structure and orienting task were incongruent i.e. when the orienting task encouraged relational processing and the list spontaneously induced item-specific processing by means of an unrelated list, recall was higher than when the combinations of list type and task were congruent i.e. an item-specific orienting task and an unrelated list. In other words, recall benefitted most when complementary processing operations were used i.e. a combination of item-specific and relational processing.

In line with this finding, previous research also suggests that item-specific and relational processing are both differentially affected by the type of pairs which are used. Epstein, Phillips and Johnson (1975) found that word pairs which were related in a conceptual way were recalled better when the orienting task focused attention on differences as opposed to similarities among the words. Presumably, pairs which are conceptually related spontaneously induce relational encoding, so additional focusing on similarities during the orienting task is of little use. However, an orienting task which draws attention to differences between words that are related induces item-specific encoding, and in combination with the spontaneously induced relational information facilitates memory recall. On the other hand, pairs with less obvious conceptual relations are recalled well when the orienting task focuses attention to similarities between the words. This is thought to be because pairs which are unrelated promote item-specific processing so an orienting task drawing attention to item similarities produces relational information which is useful.

Studies have indicated that memory performance is enhanced when both item-specific and relational information are encoded (Einstein & Hunt, 1980). Moreover, the likelihood of engaging in either forms of processing is determined by the nature of the stimuli as well as the nature of the orienting task (Einstein, McDaniel, Bowers & Stevens, 1984). For example, Hunt and Seta (1984) presented participants with categorised lists under differing orienting instructions; half were required to sort the items into categories whilst the others were instructed to rate each item for pleasantness. The materials were manipulated by varying the category size of the items, which ranged from 2 to 24 items per category. It was thought that sorting the items into appropriate categories would encourage relational encoding and rating the items for pleasantness would promote item-specific encoding. Furthermore, a bigger category size would be associated with greater spontaneous encoding of relational features. Results showed that recall was best when the category size and orienting task encouraged item-specific and relational processing. For the smaller categories (where presumably additional processing of item-specific properties is greater than it is for larger categories), recall was best when the sorting task was incorporated, as it encouraged relational processing. Conversely, recall was better for the larger categories after the pleasantness rating task, as it encouraged item-specific processing. Therefore, this suggests that a combination of both item-specific and relational processing induced via the nature of materials and the orienting task can result in superior memory performance than when either forms of processing are used alone (Gaigg, Gardiner & Bowler, 2008). Einstein and Hunt (1980) demonstrated that when item-specific processing (a pleasantness rating task) was employed in the context of highly organised stimuli (for example, conceptually categorized lists) performance was higher than when relational processing (a category sorting task) was adopted. Highest performance was brought on by both tasks and there was no difference in recall between the two tasks after each single task was performed. These results therefore demonstrate the redundant effects of using an orienting task which encourages the same type of processing as the list.

In all the studies mentioned above, the common theme seems to be that a combination of item-specific and relational processing results in better memory performance than either processing alone. Therefore, the data 'suggest that memory for a given element of an event is enhanced by encoding information about the element that is both similar to and dissimilar from other elements of the event' (Hunt & McDaniel, 1993, p.425). Indeed, both item distinctiveness and item organization appear to be important components in the encoding of to-be-remembered material. One question we can ask ourselves is whether older adults can equally benefit from item-specific and relational processing as well as younger adults, and whether they exhibit similar effects in tasks designed to evoke these types of information processing. The organisational approach suggests that older adults have a reduced tendency to make use of interrelations among items to aid memory, presumably because of their associative deficit (Naveh-Benjamin, 2000). In addition, the distinctiveness approach suggests that older adults struggle with producing unique encodings i.e. item-specific processing (Craik & Byrd, 1982). Yet research by Rankin and Firnhaber (1986) indicates that older adults are just as capable of generating as many distinctive encodings as younger adults. In their study, both age groups were presented with 40 nouns e.g. 'air' and were instructed to generate either distinctive adjectives i.e. 'foggy' (air) or common adjectives i.e. 'cold' (air) which described them. They were then asked to recall the nouns, both with no cues and with the adjectives they had generated as cues. When the distinctive encodings were reinstated during cued recall, performance of older and younger adults improved better than with common encodings. Moreover, even when the older adults were instructed to generate common encodings, they were found to generate distinctive encodings instead. These results suggest 'an item-specific encoding bias of older adults and to its memorial efficacy' (Luszcz, Roberts & Mattiske, 1990, p.243) as encoding distinctive information relies on item-specific processing, and older adults were biased to process distinctive info when asked to generate common encodings.

Luszcz et al. (1990) investigated the use of item-specific and relational information in the recall of older and younger adults. The first experiment involved only older adults, who were presented with either unrelated or related words, and were required to rate the words for pleasantness (item-specific), sort the words into categories (relational) or to perform both tasks. They were then required to recall all of the words. Learning was incidental to prevent any contaminating effects of the intent to learn. In other words, if participants were aware of the upcoming memory test, there would have been a possibility that they may have engaged in a learning strategy other than those specified, making it difficult to attribute the effects to item-specific or relational processing. In accordance with Einstein and Hunt's (1980) findings, it was predicted that recall would be better following the combined task, as opposed to following either single task, irrespective of the word type. In addition, it was also thought that memory performance would be better following a single task applied to a list which evoked complementary information i.e. the item-specific task with a related list rather than a task which induced the same kind of information i.e. the relational task with a related list.

As predicted, a combination of both forms of processing resulted in significantly better memory performance than either task alone. Moreover, performance for a given task was facilitated when the materials provided complementary information, such that recall of related words was better following the rating task, and recall of the unrelated words was better following the sorting task. Therefore, these patterns of results obtained with the older adults were similar to those obtained by Hunt and Einstein (1981) with the younger ones. It appears that older adults are capable of using both distinctive and relational information to facilitate recall of unrelated and related words. Their second experiment looked at category size, and also included a sample of younger adults so direct comparisons could be made. According to Hunt and Seta's (1984) findings on category size, the encoding of relational information becomes more likely as the size of the category increases. Conversely, the smaller the category size, the more likely it is that item-specific processing will dominate. In keeping with this view, it should therefore be expected that a form of encoding which is complementary to the one already induced by the size of the category, will produce better memory performance than a non-complementary one. In addition to investigating category size in their second experiment, Luszcz et al. (1990) also included a cued recall task to assess the effects of providing relational information at retrieval in the form of category labels. With this in mind, it was believed that for the rating task, cued recall would compensate for the absence of relational encoding, resulting in a level of recall which was more similar across category size than in free recall. On the other hand, for the sorting task, cued recall would offer information redundant to the relational information supplied during encoding. Therefore, the rating condition should result in better cued recall performance than the sorting condition, and with the smaller categories compared to the larger ones. Findings for free recall indicated that there was a typical age effect, with the younger adults recalling more than the older adults. Moreover, the task by category size interaction was significant for the younger adults, but not for the older ones. For the younger adults, categories of 2 and 4 items were recalled better following sorting than following rating, and larger categories of 8, 12 and 16 were recalled better after rating. Among the older adults, for categories containing 2 items, sorting was better than rating, and for 16 item categories, rating was better than sorting. In other words, the older adults did demonstrate similar effects to the younger adults, albeit for extreme category sizes (2 or 16 item categories). Category access was analysed as an additional measure of relational information by assessing scores of 0 or 1, the latter signifying recall of at least one item from a category, and it was discovered that the younger adults were able to access more categories than the older ones, indicating a greater utilisation of relational information by the younger than by the older subjects. With regards to the cued recall task, there was an age by orienting task interaction, in that there was no age difference in cued recall for the rated items (younger adults = 0.46, older adults = 0.44), but there was in the recall of the sorted items, with younger adults recalling significantly more of the sorted items than the older adults (0.40 vs 0.33 respectively). Therefore, memory was facilitated when the encoding and retrieval task provided complementary sources of information, especially for the older adults as their performance increased from .33 for sorting to .44 with rating. Providing further relational information at retrieval in the form of cued recall produced equivalent levels of memory performance among older and younger adults for the rated items. As written by Luszcz et al. (1980, p.247), the 'fact that cued recall produces a pattern of performance that is similar across age groups implies that provision of relational information at retrieval compensates for deficiencies observed in older adults' free recall'. Whereas the younger adults are able to benefit from complementary sources of information at encoding, this is only true for older adults when complementary sources of information are included at retrieval as well, and demonstrates the importance to older adults of using appropriate processing techniques during both encoding and retrieval. As the sorting task required relational processing techniques, it could be argued that older adults' associative deficit made it more difficult for them to effectively employ appropriate relational techniques thus resulting in a larger age difference in the sorting task than in the rating task. This further suggests that older adults primarily rely on item-specific processing, and implies that their associative deficit stems from an inability to engage in successful relational processing.

Overall then, findings from Luszcz et al. (1990) indicate that like younger adults, the memory performance of older adults can be aided by the availability of item-specific and relational information (see also Fisher & McDowd, 1993). The results imply that older adults are just as capable as younger adults of making use of and benefitting from both forms of processing. However, one important finding to note was that across both experiments, the older adults did not selectively gain from the relational encoding via the orienting task of materials thought to automatically induce item-specific information. Indeed, they showed evidence of benefitting from both types of information: 1) when they were combined at encoding, 2) when materials evoked relational information and the task provided item-specific information, and 3) when encoding and retrieval gave rise to complementary types of information. So it seems that whilst the older adults are clearly capable of benefitting from combined item-specific and relational processing, they are biased towards item-specific over relational encoding (Rankin & Firnhaber, 1986) and that they do not spontaneously depend on relational information to facilitate recall (Hultsch, 1969), again a finding coherent with the ADH. The combination from which they appear to benefit the most is when they engage in item-specific encoding of materials which are related. According to Luszcz et al. (1990), 'this combination may offset difficulties older adults have as a result of reduced processing capacity or mental agility…in that the encoding operations are compatible with their preferred mnemonic strategy and the related materials are conducive to remembering' (p.248).

Fisher and McDowd (1993) also investigated item-specific and relational processing in young and older adults. Both groups were given either related or unrelated words under instructions to sort them into categories or to rate them for pleasantness. The typical age effect was demonstrated with the younger adults recalling more than the older ones, and neither the type of word not the orienting task interacted with age, indicating that the older adults were just as able as the younger adults to utilize both forms of information. Recall was facilitated when the task and type of materials evoked complementary sorts of information i.e. related words were better remembered when they were rated for pleasantness as compared to when they were categorised, and the recall of unrelated words was superior when they were categorized relative to when they were rated for pleasantness. Thus, again it appears that a combination of item-specific and relational information benefits the memory performance of both older and younger adults. Contrary to previous findings, the results from this study suggest that older adults are not biased to item-specific processing, and that they can process items in a relational way when they are instructed to do so. Clearly then, more research is needed to clarify the roles of item-specific and relational processing in the elderly.

Researchers have also looked at whether generating item-specific information in the context of relational information can reduce age differences. Smith, Hunt and Dunlosky (2005) presented older and younger adults with sets of five words from each of 30 categories. Words were arranged vertically, and an asterisk was placed on the top item. The task involved participants making a distinctiveness judgement about the top word in comparison to the other four words i.e. what made the top word different from the other words? It was found that older adults could specifically process information to the same extent as younger adults when considerations were placed concerning what made an item unique and when such considerations took place 'in the context of highly obvious relational information' (Smith, 2006, p.7). It appears that older adults are capable of engaging in some item-specific processing in the context of relational information almost as well as younger adults.

Overall, research concerning age differences in item-specific and relational processing generally indicates that when the encoding task and materials directly encourage and support both forms of processing, age differences are reduced. This offers a plausible explanation as to why a smaller age difference was observed for the integrative pairs relative to the unrelated ones; it could be argued that the integrative pairs encourage relational processing more so than the unrelated pairs as their integrative nature spontaneously leads participants to relate items within the pairs. Without the integrative link, successfully relating the items within each pair may depend more on explicit, effortful, encoding operations, and performance suffers as a result. So the suggestion is that integrative pairs spontaneously induce relational processing, which in turn benefits both older and younger adults' memory performance, whereas the lack of relation of the unrelated pairs produces deficits amongst older adults because of their associative deficit.

The following experiment was designed to see whether the integrative advantage would be reduced when participants were directed to focus on item-specific properties of the integrative pairs. The manipulation was intended to shift the balance from relational processing of the integrative pairs to item-specific processing, potentially resulting in the integrative pairs behaving much like the unrelated ones. A further prediction was that explicitly asking participants to engage in a relational processing task with the unrelated pairs would yield a smaller age difference than would appear in the item-specific task.

2.4.2 Method

2.4.2.1 Participants

Thirty one young adults (18 female) aged 18-35 and thirty healthy older adults (24 female) aged 65-90 years took part in the experiment. Young participants consisted mainly of undergraduates at City, University of London who participated in exchange for course credit/money. The others were enlisted via advertisements placed on websites and through a university designed system which contained details of experiments. Older participants were recruited by advertisements placed in the local newspaper and through word of mouth; and were reimbursed for their travel expenses.

Both young and older participants completed the Wechsler Abbreviated Scale of Intelligence (Wechsler, 1999) as a brief measure of intelligence. An independent t-test was conducted on the IQ data for both young and older participants and revealed that IQ did not vary significantly between the two age groups ($t(59) = .131$, $p = .896$). In addition, older adults were administered with the Mini Mental State Examination 2 (Folstein & Folstein, 2012) to screen for cognitive impairment (Table 2.4). They also completed the Geriatric Depression Scale as a measure of their depression levels. Finally, for all participants, information was collected concerning their occupation and education level.

Table 2.4 The mean age and scores from the WAIS, MMSE-2, and the GDS for younger and older adults. Standard deviations are indicated in parentheses.

	Age	WAIS	MMSE-2	GDS
Younger adults	22.2 (2.7)	106.7 (8.2)	n/a	n/a
Older adults	73.4 (7.1)	105.4 (6.7)	28.2 (0.9)	6.1 (1.2)

2.4.2.2 Materials

Integrative and unrelated pairs were constructed using Google Hits as a proxy. Firstly, the range of ratings of word characteristics from the stimuli used in the previous experiment such as concreteness, familiarity etc. were input into the MRC Psycholinguistic Database to obtain words which fell within a similar range. This ensured that all the words selected would have similar ratings to stimuli used in the previous experiment and removed the possibility that any differences observed between this current experiment and the first were due to differing word characteristics i.e. some words had higher concreteness values than the other. Pairs were considered to be integrative if they could be linked together to make coherent sense. On the other hand, unrelated pairs were considered not to make coherent sense, and to be completely unrelated. To check that there was no association between the selected word pairs, associative strength was assessed using the University of South Florida Free Association Norms (Nelson, McEvoy & Schreiber, 1998). Pairs where the second member of the pair (target) appeared as a response to the first member of the pair (cue) were discarded, and pairs were selected if the target did not appear as a response to the cue. It was assumed that for the selected pairs, the second word (target) had no association to the first word (cue), so all items in the integrative non-associative and unrelated conditions had no association to each other in accordance with the USF Free Association Norms. Google hits, which gave the number of occurrences that the two words of each pair appeared together, were noted in order to equate co-occurrence ratings between the selected integrative and unrelated word pairs. Generation led to a total of 80 pairs (40 unrelated and 40 integrative), which were then rated for integratability and associativeness by students in a procedure similar to that adopted by Estes and Jones (2009) and described previously. Twenty participants at City, University of London rated the extent to which the pairs could be linked together to produce a coherent phrase. In addition, participants also rated the extent to which the words could be associated to one another on a scale from 1 (not associated) to 7 (highly associated). In total, 20 integrative and 20 unrelated pairs were selected; the chosen integrative non-associative stimuli received high ratings for integratability (M = 5.9, SD = 0.88), but low ratings for associativeness (M = 2.3, SD = 0.85), and the chosen unrelated words received low ratings for integratability (M = 2.1, SD = 0.79) as well as low ratings for associativeness (M = 2.2, SD = 0.83).

Measures of word frequency, length, imageability, familiarity, concreteness etc. for the chosen stimuli were obtained from the MRC Psycholinguistic Database, and t-tests revealed that there were no significant differences in these variables between the integrative and unrelated word pairs (see Appendix). In addition, unlike the previous experiment, co-occurrence as measured by Google Hits was equated between both pair types, with the t-test revealing no significant difference in co-occurrence between integrative and unrelated ($t(38) = .887$, $p = .381$).

2.4.2.3 Procedure

A 2 (task type: relational, item-specific) x 2 (age: old, young) x 2 (pair type: integrative, unrelated) mixed design was used. Participants were presented with both integrative and unrelated pairs on a computer using the software Visual Basic and were either instructed to perform an item-specific task, which involved rating the word of each pair for pleasantness on a scale of 1 (very pleasant) to 7 (not very pleasant), or a relational task, which involved constructing a coherent sentence in which both words of each pair were used in the order they appeared in (this was important as co-occurrence ratings were obtained for pairs appearing in a specific order). As task type was a between subjects variable, participants would not have been able to transfer the relational strategy from the relational task to the item-specific task (they only participated in one of the two tasks). The pairs were presented sequentially on the computer screen and both items of each pair appeared side by side in the centre of the screen, separated by 10 cm. The study phase was self-paced with the next pair appearing on the screen as soon as participants completed the task for each pair and clicked on the ‘next’ button. For the item-specific task, participants had to move the scroll to the required pleasantness rating using the cursor on the computer mouse, which was located underneath each word. Therefore, two ratings were required per word pair in the item-specific task. For the relational task, participants had to type a sentence containing both words in a text box located underneath the pair. The font used was Arial, with a font size of 14.The time taken (in seconds) to complete the task for each pair was recorded by the program and noted.

The procedure was incidental in order to avoid the possibilities of contamination in the two tasks. If participants were aware of the upcoming memory test, there was a danger that they would have employed strategies other than those specified to maximise the chances of successful recall. Therefore, each participant was presented with one list which contained 10 integrative and 10 unrelated word pairs randomly chosen from the set of 20 integrative and 20 unrelated pairs. Therefore, no participant received the same combination of integrative and unrelated pairs.

After all 20 pairs were presented; participants completed a distractor task for 2 minutes which involved solving a series of word anagrams. The anagram task was chosen specifically to prevent the participants from guessing that there would be an upcoming memory test as they were told that the study concerned word characteristics and how their properties could help with solving word anagrams. The distractor task was then followed by a surprise paired associate memory task where the left word of each pair was presented, with participants having to recall the right word belonging to the pair.

2.4.3 Results

The mean proportion of targets correctly recalled for each condition across both age groups is displayed in the figure below.

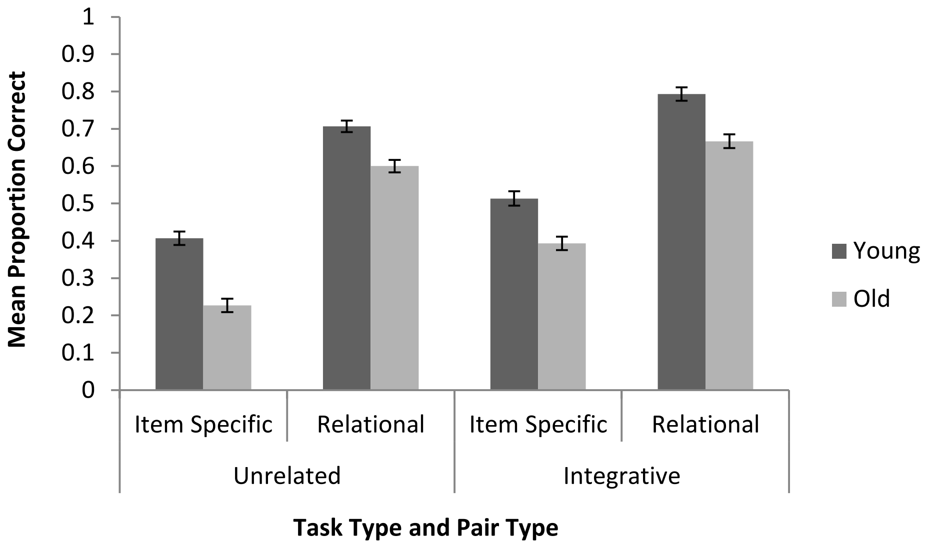

Fig 2.4 The proportion of integrative and unrelated targets recalled in the item-specific and relational tasks across older and younger adults. Error bars represent means to ±1 standard error.

From examining Figure 2.4 we can see that in each condition a greater number of targets were correctly recalled in the relational task than in the item-specific task, and that this difference appeared to be more pronounced for the older adults with the unrelated pairs in comparison to the other conditions. The age effect also seemed to be present with successful recall rates being higher for the younger adults than the older ones.

In order to ascertain whether integrative and unrelated pairs were significantly remembered differently in the item-specific and relational task, a 2 (age: young, older) x 2 (task: item-specific, relational) x 2 (pair type: integrative, unrelated) repeated measures ANOVA was conducted on the cued recall data. There was a main effect of age with the younger adults outperforming older adults, (F (1, 56) = 80.576, MSE = .533, p<.001), a main effect of pair type with integrative pairs yielding the highest performance, (F (1, 56) = 114.688, MSE = .341, p<.001), and a main effect of task type with the relational task resulting in better performance than the item-specific task, (F (1, 56) = 426.245, MSE = 2.821, p<.001).

The two way interaction between pair type and task was significant (F (1, 56) = 9.072, MSE = .027, p = .004) suggesting a bigger difference between the integrative and unrelated pairs in the item-specific than in the relational task. The interaction between age and pair type was not significant (F (1, 56) = 1.008, MSE = .003, p = .320), nor was the interaction between task and age (F (1, 56) = 1.259, MSE = .008, p = .267) suggesting that both age groups' performance improved by a similar amount with integrative pairs and with the relational task. The three way interaction between age, task type and pair type reached significance (F (1, 56) = 4.032, MSE = .012, p = .049) suggesting that the difference between the item-specific and relational task in older (relative to younger) adults was greater with the unrelated pairs than with the integrative pairs. To clarify the source of the 3-way interaction, a 2 (task type: item-specific vs relational) x 2 (pair type: unrelated vs integrative) repeated measures ANOVA was run separately for each age group. The analyses revealed that the interaction between pair type and task type was significant among the older adults (F (1, 28) = 12.600, MSE = .037, p<.001), but not for the younger ones (F (1, 28) = .504, MSE = .001, p = .484).

For younger adults, performance improved when going from the item-specific task to the relational task and this increase was similar for both the integrative (increase of 0.21) and the unrelated pairs (increase of 0.23). This is in contrast to the older adults, whose performance increased significantly more from the item-specific task to the relational task with the unrelated pairs (increase of 0.34) than with the integrative pairs (increase of 0.24). In other words, for the older adults, going from item-specific to relational processing had a greater impact on recall of the unrelated pairs than it did on recall of the integrative ones (see Figure 2.4 above).

Further break down analysis by age examining older adults' recall with the integrative and unrelated pairs using an independent t-test with task as the grouping variable revealed that although the difference between the item-specific and relational task was significant for both the unrelated ($t(28) = 15.044$, $p<.001$) and integrative pairs ($t(28) = 10.487$, $p<.001$), the difference between both tasks with unrelated pairs (0.37) was larger than with integrative pairs (0.28).

Another way to explore the 3 way interaction was to examine the age difference for each of the four conditions. This was achieved by running a 2 (age: old vs young) x 2 (pair type: unrelated vs integrative) repeated measures ANOVA separately for each task type (item-specific and relational). The analyses showed that the interaction between pair type and age was significant in the item-specific task ($F(1, 28) = 4.648$, $MSE = .014$, $p = .040$), but not in the relational task ($F(1, 28) = .492$, $MSE = .002$, $p = .489$).

Concerning the relational task, the age difference was pretty similar for the integrative pairs as it was for the unrelated pairs; in other words, the effect of age on recall did not differ significantly between integrative and unrelated pairs in the relational task. However, there was a significantly greater age difference for the unrelated pairs than the integrative ones in the item-specific task, implying that age had more of an impact on the unrelated pairs in the item-specific task than on the integrative pairs. In fact, the age difference was fairly stable across all conditions (differences of 0.12 and 0.11) apart from with the unrelated pairs in the item-specific task where it was the most pronounced (0.18 difference). This indicates that the older adults benefitted more than the younger adults from the integrative pairs when the task was item-specific. When the task was relational, older and younger adults showed similar levels of improvement with the integrative pairs; this suggests that the disproportionate advantage the older adults have with the integrative pairs relative to the younger adults becomes reduced when the task is relational.

Further break down analysis by task examining item-specific recall with the integrative and unrelated pairs using an independent t-test with age as the grouping variable showed that whereas the age-related difference was significant for both the unrelated (t (28) = 7.005, p<.001) and integrative pairs (t (28) = 4.541, p<.001), the age difference with unrelated pairs (0.18) was larger than with integrative pairs (0.12) (Figure 2.4)

To investigate whether there was a significant difference in recall between the integrative and unrelated pairs in each condition, the data were broken down by age and task type, and related t-tests were performed on the data. Paired samples t-tests revealed that the difference in recall between the integrative and unrelated pairs in the item-specific task was significant for both older (t (14) = 8.919, p<.001) and younger adults (t (14) = 5.172, p<.001) as well as in the relational task (t (14) = 3.162, p = .007 for older adults and t (14) = 4.516, p<.001 for younger ones). Inspection of the means indicated that across all conditions, the integrative pairs were recalled significantly better than the unrelated ones for older and younger adults. It seems that getting participants to engage in item-specific processing of the integrative pairs was unsuccessful in removing the integrative advantage.

2.4.4 Discussion

The main purpose of the current experiment was to see whether introducing item-specific processing with the integrative pairs would remove their advantage and make them behave like unrelated pairs. In summary, the findings are as follows. The typical age effect was replicated with the younger adults recalling more targets correctly than the older adults, and the age difference was the largest with the unrelated pairs in the item-specific task. Integrative pairs were recalled significantly better than the unrelated ones, and the relational task resulted in better performance than the item-specific task. The three way interaction between age, task and pair type was significant and suggested that the older adults benefitted more from the relational task with the unrelated pairs than the integrative ones. In contrast, the younger adults showed similar improvement from the item-specific to the relational task with the unrelated pairs as they did with the integrative ones. Therefore, for the older adults, task type had a greater impact on recall of the unrelated pairs than it did on recall of the integrative pairs. Finally, the integrative advantage was still apparent with the integrative pairs being recalled significantly better than the unrelated ones in the item-specific task.

The most notable finding of the current experiment was that explicitly directing both older and younger adults to focus on item-specific properties of the integrative pairs did not remove the integrative advantage; integrative pairs were still correctly recalled at a significantly higher rate than the unrelated pairs when the encoding task involved item-specific processing. Therefore, it seems that item-specific encoding task was not a strong enough manipulation to remove the integrative advantage. It is possible that the advantage remained because the two words of each integrative pair were encountered simultaneously; perhaps this simultaneous presentation made it highly likely that participants engaged in relational processing for the integrative pairs. Upon realisation that the words of each integrative pair could be related together in a coherent way and in a way which makes sense, relational encoding has been completed to a degree, regardless of the item-specific task. This point will be discussed in more detail further on.

The view that integrative pairs uncontrollably encourage relational processing would suggest that the relational encoding task should have had a minimal effect on performance than the item-specific task, as relational processing would be integral to the integrative pairs. However, engaging in relational processing of the integrative items did have a positive impact on recall. Clearly then, if relational processing was taking place for the integrative pairs in the context of the item-specific encoding task this relational processing was not as effective as what was induced by the relational processing task.

2.4.4.1 Integrative recall

When recall of integrative pairs was assessed, it was revealed that there was no age by encoding task interaction. In other words, for older and younger adults, the recall of integrative pairs increased similarly when going from an item-specific to relational encoding task. However, although both age groups showed similar improvements, older adults' integrative recall in the item-specific task was lower than the younger adults' integrative recall in the same task. What possible reason could there be for such a big age difference in integrative recall in the item-specific task? Craik (1986) argued that 'older adults are less likely to spontaneously engage in effortful processing' (Coane, 2013, p.1). Moreover, research has shown that older adults generally benefit from instructions which directly tell them to process items in a certain way (Erber, Galt & Botwinick, 1985; Rabinowitz, Craik & Ackerman, 1982). It could be argued that the younger adults were more able to spontaneously engage in relational processing even in the item-specific task due to greater attentional resources. Upon presentation of the integrative pairs in the item-specific task, it is likely that the younger adults were more able than the older ones to engage in automatic relational processing of the integrative pairs, despite explicit instructions to process them in an item-specific way. Such an explanation could account for the younger adults' better performance in recall of the integrative pairs in the item-specific task. The older adults were unable to effectively employ spontaneous processing and so their performance suffered as a result. In addition, the fact that the elderly benefit from directed processing instructions could mean that when they were asked to process the word pairs in an item-specific way, they focused all of their attention and resources into processing them in a way which was required by the experimenter. Therefore, they were less likely to be contaminated by the effects of spontaneous relational processing. This could be a possible explanation for the greater sensitivity among the elderly in the item-specific task for the integrative pairs.

2.4.4.2 Age differences

As expected, the typical age effect was replicated overall with the younger adults recalling significantly more items correctly than the older participants. This is not surprising given their associative deficit (Naveh-Benjamin, 2000) as well as their limited spontaneous use of strategies (Craik, 1986). However, the interaction between age and pair type did not reach significance, indicating that the integrative pairs equally benefitted both older and younger adults. Similarly, the interaction between age and task type did not reach significance either, indicating that the relational task led to similar levels of improvement in performance for both the young and older adults. This is in line with previous research which states that older adults benefit as well as the younger ones when relational tasks are used (Fisher & McDowd, 1993; Luszcz et al., 1990).

In accordance with the previous experiment, integrative pairs were found to reduce the age related deficit typically portrayed by the elderly; although the interaction between pair type and age was not significant, smaller age differences were observed in recall of the integrative pairs than the unrelated ones regardless of task. In accordance with the ADH (Naveh-Benjamin, 2000) the largest age difference was obtained in recall of the unrelated pairs than in recall of the integrative ones regardless of task as older adults would have struggled considerably forming new associations. The fact that the age difference was considerably reduced with these unassociated integrative pairs suggests that these integrative pairs possess some other qualities/characteristics apart from prior association which are beneficial in reducing the associative deficit typically found for older adults. Indeed the largest age difference was observed for recall of the unrelated pairs in the item-specific task. As this task did not explicitly require participants to form new associations, it is unclear why younger adults' memory was better than that of the older adults for the unrelated items in the item-specific task. Such a difference may simply reflect age differences in memory in that the younger adults were able to encode and hence retrieve the unrelated pairs better, even when they were instructed to focus on item-specific properties. Perhaps when presented with unrelated pairs, the lack of any obvious connection or association between the items prevents older adults from being able to successfully/spontaneously encode them in memory, irrespective of the task they are required to perform on the pairs. Conversely, as younger adults are more equipped to encode new associations, they are therefore more likely to store and hence retrieve items with no pre-existing associations, regardless of the task. The two items of the unrelated pairs shared a temporal and spatial context as they were presented contiguously on the same screen. If younger adults spontaneously associate this context with the items more readily and easily and are more able to use this to support retrieval then it would make sense for younger adults performance to be better for the unrelated pairs in the item-specific task. Even though the encoding task does not focus on the relational/shared context information, it does not mean that it is not processed/encoded.

An advantage was still apparent for the younger adults in comparison to the older adults in the relational task with the integrative pairs. It is possible that the younger adults performed better in the relational task with the integrative pairs because they are better capable of deploying attentional resources to explicitly process the items in a relational way. The ADH (Naveh-Benjamin, 2000) can also provide an explanation why younger adults performed better with the relational task as it suggests older adults have a reduced tendency to make use of interrelations among items to aid memory. Indeed in a study by Luszcz et al. (1980) category access was analysed as an additional measure of relational information. Findings indicated that younger adults were able to access more categories than the older ones, demonstrating a greater utilisation of relational information by the younger than by the older adults. Therefore, the older adults do not spontaneously depend on relational processing to facilitate recall (Hultsch, 1969).

2.4.4.3 Complementary forms of processing

Previous research would suggest that when complementary forms of processing are induced by the nature of the materials as well as by the task, both age groups are able to benefit more so than when the same type of processing is employed (Epstein et al., 1975; Einstein & Hunt, 1980;

Hunt & Einstein, 1981). In other words, when an orienting task is used which encourages the same type of processing brought on by the list; the effects are redundant as similar processing is induced (Einstein et al., 1990). Let us consider the stimuli in the present study – it is thought that the unrelated pairs automatically promote item-specific processing as there is no obvious relationship between them whereas the integrative pairs spontaneously induce relational encoding. Therefore, an item-specific orienting task is of little use to the unrelated pairs and a relational task is of little benefit to the integrative pairs. Based on this research, one would expect performance to be better for the unrelated pairs following the relational task as opposed to the item-specific task, and better for the integrative pairs following the item-specific task as opposed to the relational task. In accordance to previous literature, cued recall was facilitated for the unrelated pairs in the relational task in comparison to the item-specific task across both age groups. As there was no obvious conceptual relation between unrelated word pairs, constructing a sentence which linked the two words together would have encouraged participants to engage in relational processing, which was beneficial to recall (Hunt & Einstein, 1981). However, cued recall was not facilitated for the integrative pairs in the item-specific task compared to the relational task for both age groups. One possible reason for this could be that in all the previous studies investigating item-specific vs relational processing, lists of single items were used (rather than pairs) where words were encountered all at once. For example, consider a set of items which belong to several different categories, and where each category contains approximately 6 items. These items spontaneously promote relational processing (as they are categorised) and an appropriate relational task would involve sorting the items into their appropriate categories. As such it would require that all the items would be exposed to participants at the same time. An appropriate item-specific task would be to indicate how word A is different from word B thus focusing on distinctive properties. In this case, it is expected that the item-specific task would be more beneficial as participants are able to look at all the singular items at once, discover the shared conceptual relations, and use distinctiveness to increase each item's uniqueness and saliency. However, in the present experiment, pairs were used and were encountered one at a time, with the next pair appearing only after completion of the orienting task. Rating each item of an integrative pair for pleasantness and then being presented with the next pair is of little benefit as participants are unable to use distinctive information in the context of shared information (the shared information in this case was the single integrative pair whereas in previous studies it was the whole list of relational items). On the other hand, the relational task is likely to benefit the integrative pairs as the sentence construction task makes a specific link between those items – in essence it can be construed as involving item-specific processing as each relational link being made by the sentence task makes each pair distinctive relative to the rest. Therefore, a combination of item-specific and relational processing is being used, which is believed to lead to superior memory performance than when only one type of processing is used (Einstein & Hunt, 1980; Hunt & Seta, 1984; Hunt & McDaniel, 1993; Luszcz et al., 1990). Thus 'memory for a given element of an event is enhanced by encoding information about the element that is both similar to and dissimilar from other elements of the event' (Hunt & McDaniel, 1993, p.425). In accordance with this, the relational task did benefit the integrative pairs more so than the item-specific task across older and younger adults.

The relational task overall resulted in better memory performance than the item-specific task for both older and younger adults. The sentence construction task enabled pairs to be related together in a coherent and plausible way, and it could be argued that as the memory task was a cued recall one, it increased the encoding-retrieval match which is thought to be beneficial to memory performance (Tulving, 1983). Conditions at retrieval matched those at encoding which is why performance benefitted from the relational task more so than from the item-specific task. The encoding retrieval match states that performance is determined by the degree of overlap or match between the conditions during encoding and those during retrieval (Tulving, 1983). The greater the match or overlap between study and test, the better the performance. Hannon and Craik (2001) demonstrated that participants were more accurately able to recall a target word which was part of an unrelated pair when they were given the unrelated cue than when they were given a semantically related word which was not present during encoding. In addition, the strength of the cue doesn't make much of a difference to recall as long as the weak or strong word was present at encoding; participants were found to equally benefit from a weakly related cue as from a strongly related cue (Adam, Van der Linden, Ivanoiv, Juillerat, Bechet & Salmon, 2007). In terms of the present experiment, the relational task provided a greater match/overlap to the cued recall test as the task required them to use an associative technique to relate the words together. In order to perform well on a cued recall test one must have created and encoded an associative link between the cue and target, which the relational task would have provided. On the other hand, although there is still a match in the item-specific task as the same cues are present in the cued recall test, the degree of overlap is not as high as it is with the relational task, which more closely resembles the cued recall test. The pleasantness task does not induce associative processing and as such does not provide as close a fit to the cued recall procedure as the relational task.

As mentioned in the results, the three way interaction between age, task type and pair type was significant, and break down analysis by age revealed that the interaction between pair type and task type was significant among the older adults, but not for the younger ones. The relational task clearly benefitted older adults' unrelated recall more so than their integrative recall, whereas for younger adults, their integrative and unrelated recall increased in similar magnitude from the item-specific to the relational task. Therefore, for the older adults, the relational task had a greater impact on recall of the unrelated pairs than the integrative ones, and for younger adults, the relational task had a similar effect on both integrative and unrelated pairs. This can be explained by the older adults' relatively poor performance in recall of the unrelated pairs in the item-specific task. As the elderly possess an associative deficit (Naveh-Benjamin, 2000) they have difficulty forming novel associations between unrelated items, and in conjunction with the pleasantness rating task would have focused on individual items rather than on their associations (or lack of). Their relatively poor performance with the unrelated pairs in the item-specific task meant that the relational task had greater positive impact on associative recall of the unrelated pairs. Further break down analysis by task indicated that, in the case of the item-specific encoding task, the older adults' recall increased significantly more from unrelated to integrative pairs than the younger adults. However, in the relational task, going from the unrelated to the integrative pairs led to a comparable increase in recall for older and younger adults. So, clearly pair type had a greater effect on recall for the older adults than the younger adults in the item-specific task. In the item-specific task, absence of relational information could have meant that the older adults made extra use of the relational properties of the integrative pairs, and were able to benefit more from their use than the younger adults, presumably because of their associative deficit (which would have meant their performance was initially lower with the unrelated pairs in the item-specific task). In contrast, as the sentence construction task would have provided relational information already, the beneficial relational effects of the integrative pairs would have had less impact on older adults' recall. In other words, the beneficial effects of the integrative pairs on recall would have been less potent in the sentence construction relational task as relational info would have already been provided, explaining why age did not interact with pair type in the relational task.

2.4.4.4 Design limitations

As mentioned previously, one potential limitation of the design was that word pairs were presented simultaneously on the screen, even in the item-specific task. It is possible that although participants were instructed to engage in the item-specific task by first rating the word on the left for pleasantness followed by the right word, they noticed and processed the integrative pairing. So the failure to remove the integrative advantage in the item-specific task could have resulted from the presentation format of the word pairs. If the items within each pair were to be presented one at a time, rather than simultaneously, this could lead to a similar level of recall between the integrative and unrelated pairs in the item-specific task.

It could also be argued that the relational sentence construction task was more elaborative than the item-specific pleasantness rating task; this difference in processing could account for the superior recall found for the relational relative to the item-specific task. Constructing a coherent sentence involves imagination as well as semantic thinking and grammar skills i.e. whether the sentence makes sense, whether it is plausible and grammatically correct. It involves thinking of a scenario and as such requires participants to engage in deeper and more elaborative processing involving higher cognitive skills. In other words, it is more cognitively demanding. According to Kang (2010) 'effortful retrieval promotes the activation of more elaborative information, relative to less effortful retrieval or rereading, hence establishing more retrieval routes and increasing later retention' (p.1009). The pleasantness rating task does involve thinking on a semantic level too, as prior experience and long term knowledge is used in order to decide whether a word is very pleasant or unpleasant. For example, imagine a participant is presented with the word 'dog' and asked to rate its pleasantness. Such a participant may have had an unfortunate experience with a dog in the past, leading them to remember that specific episode and to rate the word as unpleasant. Therefore, a degree of elaboration does occur however it is the amount of elaboration which varies between the two tasks. An additional constraint of the sentence construction task is that participants must utilise a 'grammar check' to see whether the sentence makes grammatical sense or not. Broadly speaking then, elaboration 'refers to the process of encoding more features or attributes to the representation of an event' (Karpicke & Smith, 2012, p.18).

Clearly, a greater amount of elaboration was involved in the relational task which is why performance was facilitated. This elaboration viewpoint could also explain the age differences observed in the relational task. It could be argued that the reason the older adults recalled less integrative and unrelated targets in the relational task than younger adults is because they demonstrate a reduced tendency to generate and elaborate on associative processes which the relational task would have required them to do so.

Therefore, the amount of elaboration could explain and account for the superiority of the relational task over the item-specific task; constructing a sentence involves much more complex thinking and detailed thought (sentences had to be coherent as well) than simply rating a word for pleasantness. As a result, the pleasantness task may not have successfully directed attention enough to the item-specific properties of the words because of decreased elaboration. Therefore, differences in elaboration rather than differences in processing may have brought on the heightened memory performance of the integrative pairs in the item-specific task. If the amount of elaboration between the two tasks was better controlled and equated, this would give a much more reliable measure of the differences in memory produced by item-specific and relational processing. A logical step would therefore be to equate the amount of elaboration between the two tasks. If differences are still apparent between the item-specific and relational tasks then we can conclude with certainty that the amount of elaboration was not a factor.

In conclusion, a combination of both presentation format and differences in elaboration could offer an explanation as to why the integrative advantage was still apparent in the item-specific task. An experiment where the words from each pair are presented one at a time, together with an item-specific task better equated on elaboration with the relational task should maximise the likelihood of integrative pairs behaving like unrelated ones.

2.5 Experiments 3a and 3b

The aim of experiments 3a and 3b was to address potential problems with the design of Experiment 2. Experiment 3a only involved younger adults, while in Experiment 3b only older adults were tested. As the same design was used in both 3a and 3b the results of each could be analysed together to test for age effects. In both experiments the impact of item-specific and relational encoding task was again investigated, while comparing simultaneous and sequential presentation of the items within each pair.

The primary goal/intention of Experiment 3a was to test the hypothesis that suggests that the integrative and unrelated pairs mainly differ in terms of the amount of relational processing they spontaneously support. More specifically, it was hypothesized that the integrative advantage would be significantly reduced or abolished under conditions where item-specific processing was central to the encoding task and when the words of each pair were presented one at a time; likewise, it was assumed that the relative disadvantage of the unrelated pairs would be minimised when relational processing was the main component of the encoding task. The same pattern of predictions was hypothesised for Experiment 3b, albeit with lower recall overall. Predictions regarding the combined examination of Experiments 3a and 3b will be presented prior to their joint analysis. Additional stimuli were constructed, and worldwide Google hits were obtained as well as UK Google hits as measures of co-occurrence.

2.5.1 Method

2.5.1.1 Participants

Sixty young adults (38 female) aged 18-32 and sixty older adults (45 female) aged 65-82 took part in the experiment. Young participants consisted mainly of undergraduates at City, University of London who participated in exchange for course credit/money.

Both groups completed the Wechsler Abbreviated Scale of Intelligence (Wechsler, 1999) as a brief measure of intelligence, and an independent t-test revealed no significant difference in IQ between the older and younger adults ($t(118) = .408$, $p = .684$). In addition, older adults were administered with the Mini Mental State Examination 2 (Folstein & Folstein, 2012) to screen for cognitive impairment (Table 2.5). They also completed the Geriatric Depression Scale as a measure of their depression levels. Finally, for all participants, information was collected concerning their occupation and education level.

Table 2.5 The mean age and scores from the WAIS, MMSE-2, and the GDS for younger and older adults. Standard deviations are indicated in parentheses.

	Age	WAIS	MMSE-2	GDS
Younger adults	21.6 (2.4)	107.8 (6.9)	na	Na
Older adults	71.4 (6.4)	105.8 (7.3)	28.5 (1.1)	4.5 (1.4)

2.5.1.2 Materials

As measures of local co-occurrence, worldwide Google hits were included in the selection of stimuli as well as UK Google hits. Integrative and unrelated pairs from the previous study were used, and additional stimuli were constructed to equate the integrative and unrelated pairs on UK and worldwide Google hits. The same selection procedure used in the previous experiment was adopted to select appropriate stimuli, with the exception that a bigger set of stimuli was identified. This was necessary as more experimental conditions meant that more pairs had to be constructed. Once a set of 50 integrative and 50 unrelated word pairs were finalised, a small sample of 20 students rated the integratability of the word pairs and a total of 30 integrative (mean integratability score: 5.8, SD = 0.83) and 30 unrelated pairs (mean integratability score: 2.1, SD = 0.64) were chosen.

Measures of word frequency, length, imageability, familiarity, concreteness etc for the chosen stimuli were obtained from the MRC Psycholinguistic Database, and t-tests revealed that there were no significant differences in these variables between the integrative and unrelated word pairs (see Appendix). In addition, t-tests revealed no significant differences in co-occurrence measured through worldwide ($t(38) = .154$, $p = .878$) and UK Google hits ($t(38) = 1.083$, $p = .286$) between unrelated and integrative pair types.

2.5.1.3 Procedure

A 2 (pair type: integrative, unrelated) x 2 (task type: relational, item-specific) x 2 (presentation format: simultaneous, one at a time) mixed design was incorporated. The decision was made to first run the experiment with the younger adults to test the procedure as a whole and some of the hypotheses. Participants were presented with both integrative and unrelated pairs on the computer using the software Visual Basic, with the words of each pair either appearing at the same time (as in the previous experiment) or one at a time (with the left word being presented first and the right word being presented upon completion of the required task). Words were presented in lower case, in Arial font, with a size of 14. Each participant either had to construct a sentence which included each word (item-specific task) or they had to construct a sentence which included both words (relational task). Therefore, the item-specific task involved constructing two sentences for each pair, whereas the relational task only involved constructing one sentence. Each list consisted of 10 integrative and 10 unrelated word pairs mixed randomly within the list. As the item-specific task was now a sentence generation activity, this equated the amount of elaboration between the two tasks (they both involved constructing sentences). As with the previous experiment, the procedure was incidental, which meant that only one list could be presented to each participant to avoid the possibilities of contamination. After all the word pairs from each list were presented, a distractor task was administered in which participants had to solve a series of word anagrams in 2 minutes. This was then immediately followed by the surprise paired associate memory task where the left word of each pair was presented, with participants having to verbally recall the right word and type it on the computer. Presentation of the words in the memory task was randomized, and recall was self-paced, although participants were encouraged not to spend too long on recalling the corresponding word.

2.5.2 Results and discussion

2.5.2.1 Younger adults

The proportion of targets correctly recalled per condition is illustrated in the figure below.

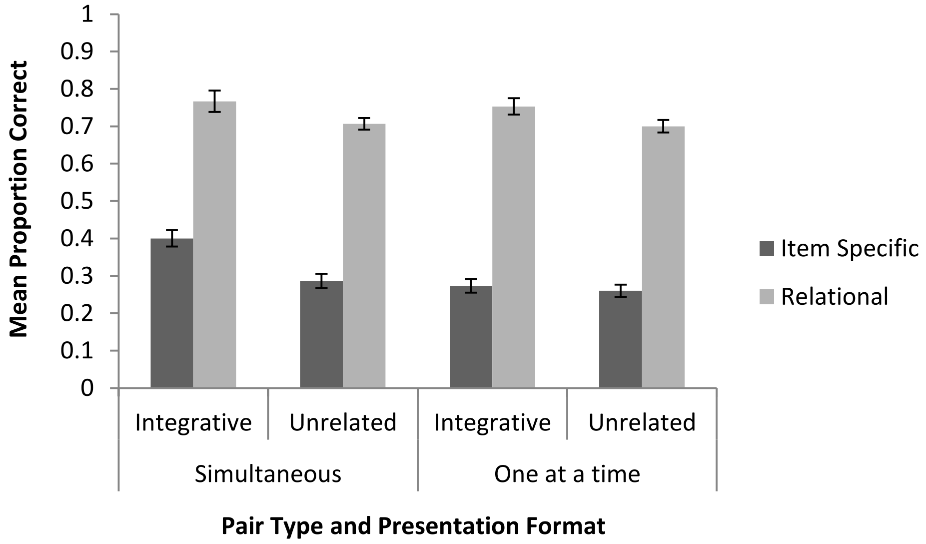

Fig 2.5 Proportion of targets recalled per condition for the young adults. Error bars represent means to ±1 standard error.

Figure 2.5 suggests that relational processing produced much higher performance than item-specific processing. Moreover, it would seem that item-specific processing produced the same level of performance in all conditions, except when integrative pairs were presented simultaneously. This is some evidence that performance for the integrative pairs in the relational processing condition might also be higher than performance for the unrelated pairs with relational encoding. Inferential statistics confirmed these observations. Data was submitted to a 2 (pair type: integrative, unrelated) x 2 (task: item-specific, relational) x 2 (presentation format: one at a time, simultaneous) repeated measures ANOVA. Pair type was significant ($F(1, 56) = 39.273$, $MSE = .108$, $p<.001$) with the integrative pairs yielding higher performance than the unrelated pairs. The relational task resulted in significantly better performance than the item-specific task ($F(1, 56) = 578.502$, $MSE = 5.461$,

$p<.001$). Also, recall was higher with simultaneous presentation than with one at a time presentation ($F(1, 56) = 5.967$, $MSE = .056$, $p = .018$).

Pair type significantly interacted with presentation format ($F(1, 56) = 7.758$, $MSE = .021$, $p = .007$). However, the interaction between pair type and task type was not significant ($F(1, 56) = .121$, $MSE = .000$, $p = .729$) which implies that the increase in recall from the unrelated to the integrative pairs was similar across both the relational and the item-specific task. The interaction between presentation and task type also failed to reach significance ($F(1, 56) = 3.531$, $MSE = .033$, $p = .065$), suggesting a similar improvement in performance from the one at a time presentation to the simultaneous presentation in both the item-specific and the relational task.

The three way interaction between pair type, task type and presentation format reached significance ($F(1, 56) = 5.939$, $MSE = .016$, $p = .018$) and was broken down by task type and a 2 (pair type: unrelated vs integrative) x 2 (presentation format: simultaneous vs one at a time) repeated measures ANOVA revealed that the interaction between pair type and presentation format was significant in the item-specific task ($F(1,28) = 28.125$, $MSE = .037$, $p<.001$) but not in the relational task ($F(1, 28) = .040$, $MSE = .000$, $p = .843$). The means from Figure 2.5 have been reproduced in the figures below for clarity.

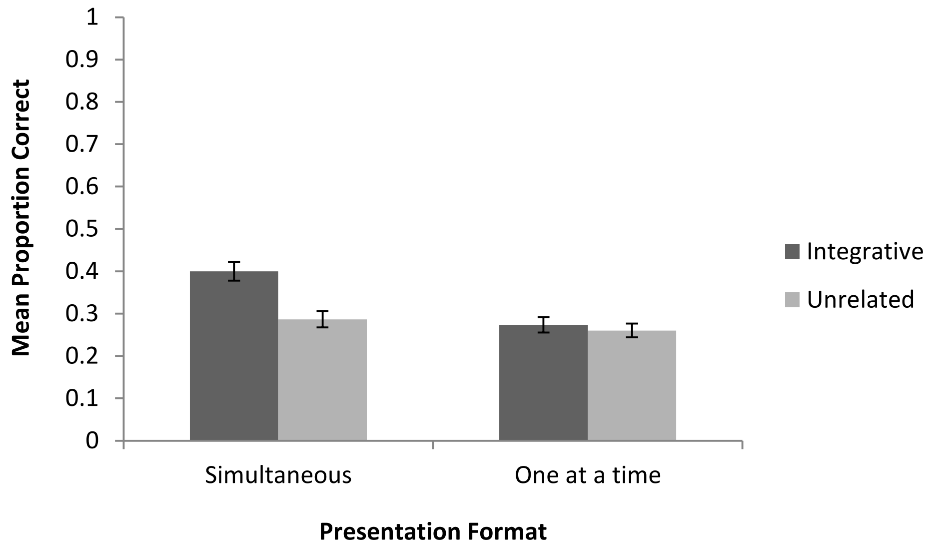

Fig 2.6 Proportion of integrative and unrelated targets recalled in the item-specific task with one at a time and simultaneous presentation. Error bars represent means to ±1 standard error.

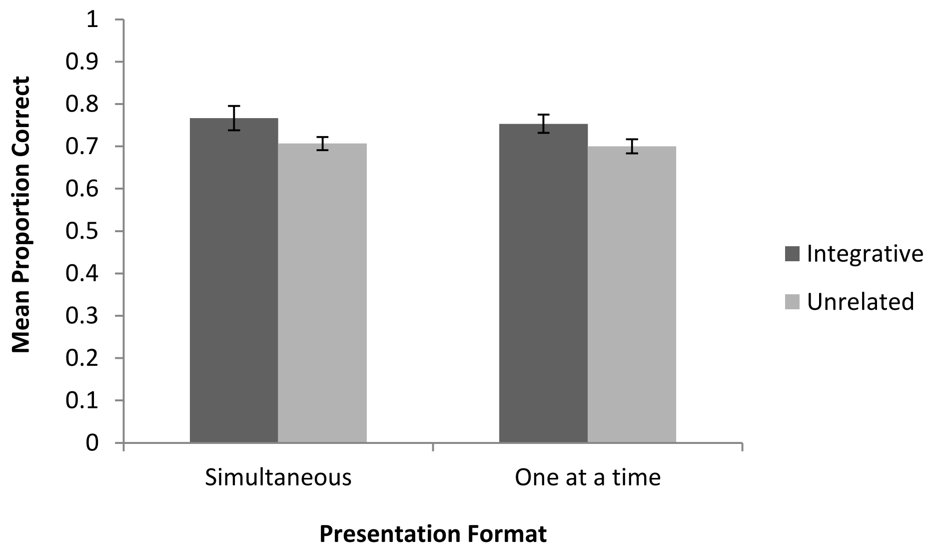

Fig 2.7 Proportion of integrative and unrelated targets recalled in the relational task with one at a time and simultaneous presentation. Error bars represent means to ±1 standard error.

Upon examination of memory performance in the item-specific task (Fig 2.6), we can see that there was a greater effect of pair type on recall in simultaneous presentation than in one at a time presentation as performance increased more from unrelated to integrative pairs with simultaneous presentation than with one at a time presentation (increase of 0.11 vs increase of 0.01). In contrast, in the relational task (Fig 2.7) pair type had a similar impact on recall with simultaneous presentation as it did with one at a time presentation as performance increased from unrelated to integrative pairs by 0.05 for one at a time presentation and by 0.06 for simultaneous presentation. Additional break down analysis using a paired samples t-test in the item-specific task confirmed these observations as there was a significant difference in recall between the integrative and the unrelated pairs with simultaneous presentation, ($t(14) = 6.859$, $p<.001$) but not in the one by one presentation mode ($t(14) = 1.468$, $p = .08$). Therefore, it appeared that the one by one presentation in conjunction with the item-specific task was successful in removing the integrative advantage. Further paired samples t-tests in the relational task also revealed that the difference in recall between the integrative and unrelated pairs was significant where words were presented one at a time ($t(14) = 2.779$, $p = .008$) and when they were presented simultaneously ($t(14) = 2.201$, $p = .023$). Therefore, across both presentation formats in the relational task, the integrative pairs were still recalled significantly better than the unrelated ones. As mentioned previously, the interaction between pair type and presentation format reached significance, however, break down analysis of the three way interaction indicated that this was attributable to the results within the item-specific conditions.

In order to explore the findings further, integrative recall was analysed separately by running a 2 (task: item-specific vs relational) x 2 (presentation format: one at a time vs simultaneous) univariate ANOVA. The means are displayed in the following figure:

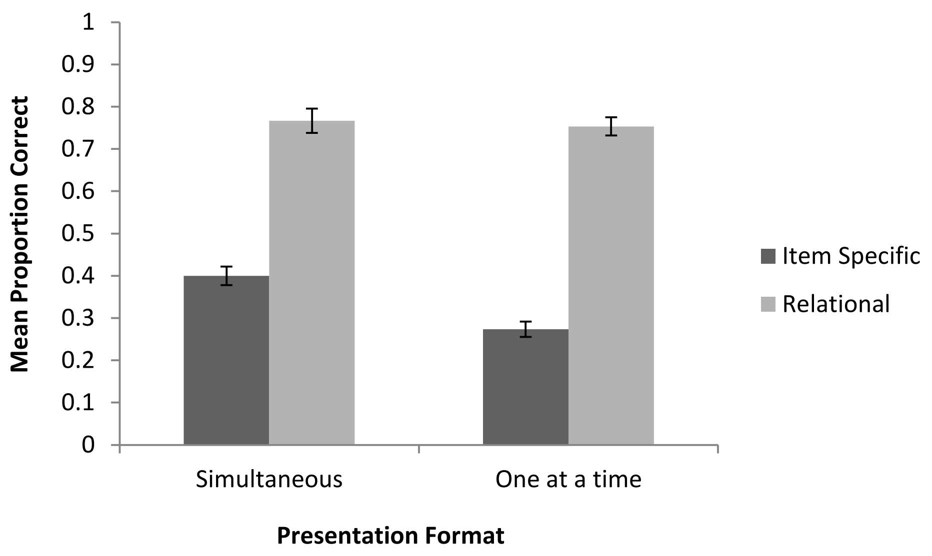

Fig 2.8 Proportion of integrative targets recalled across one at a time and simultaneous presentation in the item-specific and relational task. Error bars represent means to ±1 standard error.

It seems that presentation format appears to have a greater impact on integrative recall in the item-specific task than in the relational task. This was confirmed by the ANOVA as there was a significant task by presentation interaction (F (1, 56) = 6.130, MSE = .048, p = .016). Further break down analysis by splitting the file according to task and running an independent t-test with presentation as the grouping variable indicated there was a significant effect of presentation in the item-specific task (t (28) = 4.461, p<.001), but not in the relational task (t (28) = .371, p=.713).

Unrelated recall was also analysed separately in the same way as above. The means are displayed in the figure below:

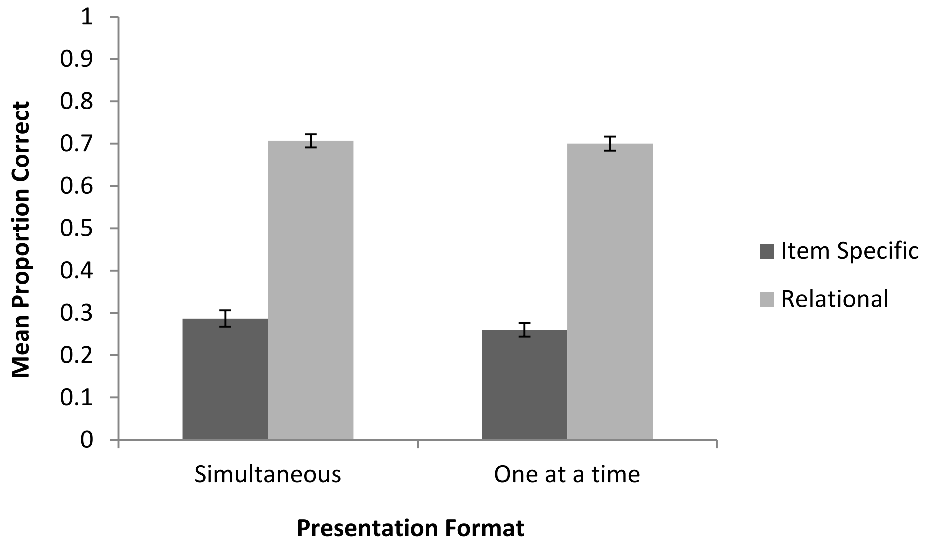

Fig 2.9 Proportion of unrelated targets recalled across one at a time and simultaneous presentation in the item-specific and relational task. Error bars represent means to ±1 standard error.

It appears that presentation format has a similar impact on unrelated recall in the item-specific task as it does in the relational task. This was confirmed by the univariate ANOVA as there was no significant interaction between task and presentation format ($F (1, 56) = .346$, $MSE = .002$, $p = .559$). This separate break down of integrative and unrelated recall provides an additional way of deconstructing the three way interaction: for integrative pairs, presentation had a significantly greater impact on recall in the item-specific task than in the relational task, whereas for unrelated pairs, presentation had a similar effect on recall, regardless of the type of task.

As expected, it appeared that the addition of a varying presentation format as well as a more elaborative item-specific task was successful in removing the integrative advantage in the item-specific task for younger adults; no significant difference in recall was documented between integrative and unrelated pairs in the item-specific task when the words of each pair were presented one at a time. It seemed that focusing on item-specific properties of the integrative pairs when the words were singularly presented prevented participants from successfully integrating the pairs together and benefitting from their advantageous property. This suggests that the individual words making up the integrative pair must be encountered at the same time in order for appropriate relational processing to take place and stresses the importance of engaging in successful relational processing of the integrative pairs for their advantage to manifest itself.

In the previous experiment, it was thought that a combination of the less elaborative item-specific task as well as the simultaneous presentation mode was responsible for the prevalent integrative advantage in the item-specific task, as relational processes were uncontrollably employed by participants. So based upon the view that relational processing of the integrative pairs is not under strategic control, then presentation format should not be expected to reduce the integrative advantage as such processing could still occur despite the words not appearing together. But when we now consider that a more elaborative cognitively demanding item-specific task was used in the present experiment, then one might expect a reduced likelihood of participants being able to uncontrollably engage in relational processing as resources are limited due to extra cognitive processes allocated to constructing a single sentence. Therefore, it seems reasonable to suggest that one by one presentation in conjunction with a more elaborately demanding item-specific task was responsible for the removal of the integrative advantage in item-specific task. This perspective could be investigated in the future by manipulating the presentation format and elaboration of the item-specific task so that a less elaborative task i.e. pleasantness is used as well as a more elaborative one i.e. sentence construction for individual words to see whether a significant difference between integrative and unrelated pairs is documented in the less elaborative one by one presentation.

Difference in recall between the integrative and unrelated pairs was significant in the item-specific task when items were presented simultaneously, indicating that the integrative advantage may have been partly due to fact that the integrative words appeared together; seeing the integrative words side by side most likely led to uncontrollable relational processing of the integrative words, even in the item-specific task.

With unrelated words presentation is unlikely to have much of an effect, as seeing unrelated words appear together is not likely to uncontrollably promote relational processing; without an associative or integrative link to bind or relate the words together, the chances of engaging in relational processing without instruction are remote. This was confirmed by the analysis above with unrelated pairs, as presentation did not have a significant effect on unrelated recall in the item-specific task or in the relational task. Clearly then, presentation had no significant impact on recall of the unrelated pairs for younger adults. In contrast, there was a significant effect of presentation on the integrative pairs in the item-specific task but not in the relational task.

An interesting finding was that even in the relational task across both presentation formats, the integrative advantage was still apparent; integrative pairs were recalled significantly better than the unrelated pairs. Based on the belief that the integrative advantage is maintained and explained by relational processing, we would expect that the relational processing of the unrelated pairs would have led to a similar level of performance to the integrative pairs. Yet the integrative advantage was maintained, suggesting that the integrative pairs possess some other component, other than relational processing, which could possibly explain their advantage. If the integrative advantage were solely due to relational processing, then perhaps one might expect both integrative and unrelated pairs to be recalled equally well when relational processing was introduced; however this wasn't the case with the advantage still being present in the relational task.

Therefore, it would seem that a combination of a more elaborative item-specific task together with a greater emphasis placed on processing the word of each pair in an item-specific way led to the removal of the integrative advantage. This highlights the uncontrollable aspect of integrative pairs and how they must be encountered at the same time for their advantage to manifest itself.

2.5.2.2 Older adults

The mean proportion of targets correctly recalled per condition is illustrated in the figure below.

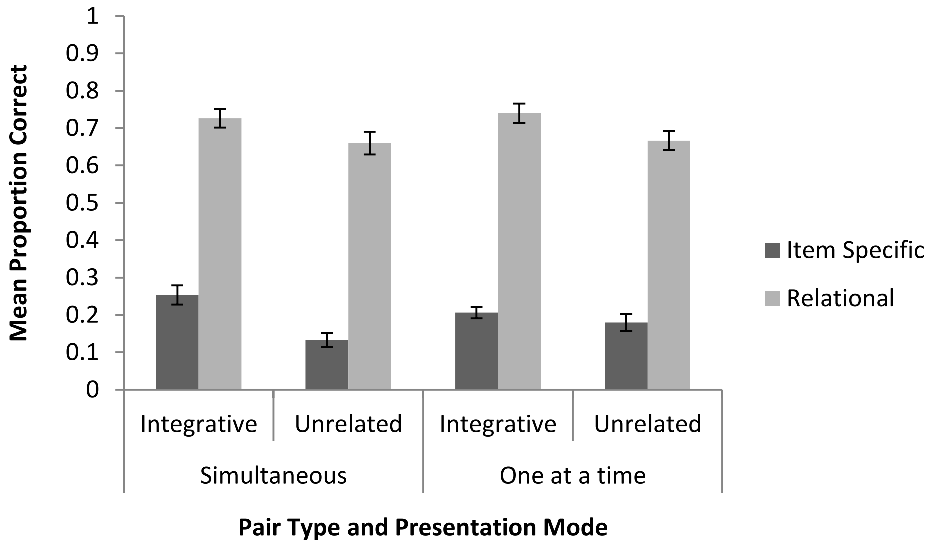

Fig 2.10 Proportion of integrative and unrelated targets recalled in the item-specific and relational task with one at a time and simultaneous presentation for the older adults. Error bars represent means to ±1 standard error.

Figure 2.10 suggests that relational processing produced much higher performance that item-specific processing. In addition, it seems that across all conditions, more integrative pairs were correctly recalled than unrelated pairs. There is also some evidence that performance for the integrative pairs in the relational processing condition might also be higher than performance for the unrelated pairs with relational encoding. Inferential statistics confirmed these observations.

Data was submitted to a 2 (pair type: integrative, unrelated) x 2 (task: item-specific, relational) x 2 (presentation format: one at a time, simultaneous) repeated measures ANOVA. The integrative pairs were recalled significantly better than the unrelated pairs ($F(1, 56) = 58.302$, $MSE = .154$, $p<.001$) and the relational encoding task led to better performance than the item-specific task ($F(1, 56) = 528.506$, $MSE = 7.651$, $p<.001$); however there was no main effect of presentation format (simultaneous vs one-by-one) ($F(1, 56) = .052$, $MSE = .001$, $p = .821$).

Pair type significantly interacted with presentation format ($F(1, 56) = 5.329$, $MSE = .014$, $p = .025$). However, the interaction between pair type and task type did not reach significance ($F(1, 56) = .032$, $p = .860$) which implies that the increase in recall from the unrelated to the integrative pairs was similar across both the relational and the item-specific task. The interaction between presentation and task type also failed to reach significance ($F(1, 56) = .052$, $MSE = .001$, $p = .821$) suggesting a similar improvement in performance from the one at a time presentation to the simultaneous presentation in both the item-specific and the relational task.

The three way interaction between pair type, task type and presentation format reached significance ($F(1, 56) = 7.095$, $MSE = .019$, $p = .010$) and was broken down by task type and a 2 (pair type: unrelated vs integrative) x 2 (presentation format: one at a time vs simultaneous) repeated measures ANOVA revealed that the interaction between pair type and presentation format was significant in the item-specific task ($F(1, 28) = 19.600$, $MSE = .033$, $p<.001$) but not in the relational task ($F(1,28) = .046$, $MSE = .000$, $p = .832$). The means have been reproduced in the following figures for clarity:

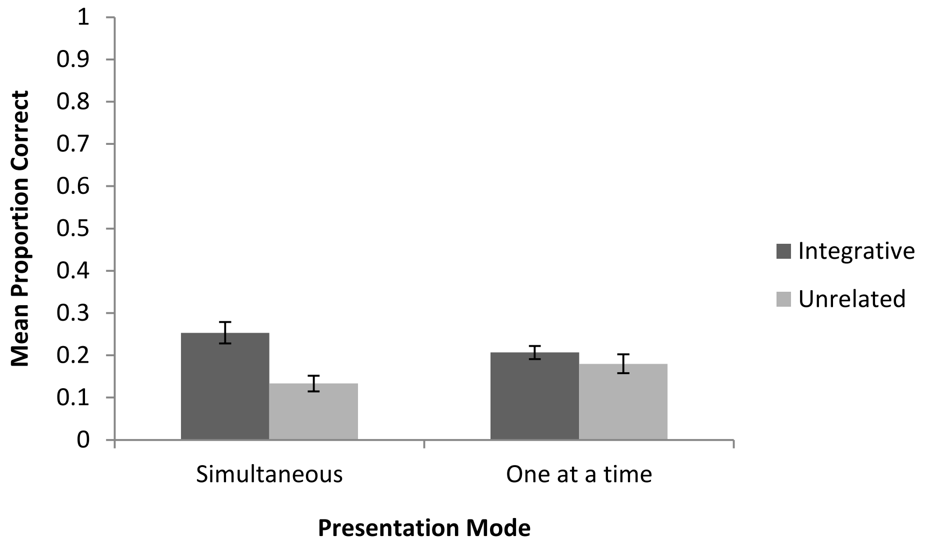

Fig 2.11 Proportion of integrative and unrelated targets recalled in the item-specific task with simultaneous and one at a time presentation for older adults. Error bars represent means to ±1 standard error.

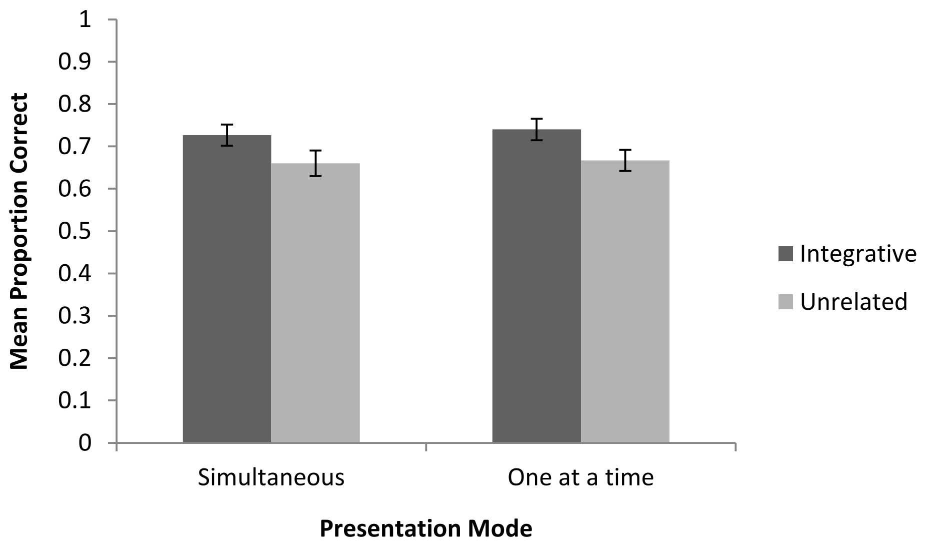

Fig 2.12 Proportion of integrative and unrelated targets recalled in the relational task with simultaneous and one at a time presentation for older adults. Error bars represent means to ±1 standard error.

From looking at memory performance in the item-specific task (Fig 2.11) we can see that pair type had a greater impact on recall with simultaneous presentation than with one at a time presentation as performance increased more from unrelated to integrative pairs with simultaneous presentation than with one a time presentation (increase of 0.12 vs increase of 0.03). In contrast, in the relational task (Fig 2.12) pair type had a similar impact on recall in simultaneous presentation as it did in one at a time presentation as performance increased by a similar magnitude from unrelated to integrative pairs (increase of 0.07). Therefore, in the relational task, recall with simultaneous and one at a time presentation was not differentially affected by whether the pair was integrative or not. In contrast, for the item-specific task, being presented with an integrative pair clearly made more of a difference to simultaneous presentation than to one at a time presentation. Additional break down analysis using a paired samples t-test in the item-specific task confirmed these observations as there was a significant difference in recall between the integrative and the unrelated pairs with simultaneous presentation, (t (14) = 8.290, $p<.001$) but not in the one by one presentation mode (t (14) = 1.740, p = .052). Therefore, the one by one presentation together with the item-specific task was successful in removing the integrative advantage. Further paired samples t-tests also revealed that the difference in recall between the integrative and unrelated pairs was significant in the relational task where words were presented one at a time (t (14) = 4.036, $p<.001$) and when they were presented simultaneously (t (14) = 2.646, p = .010). Therefore, across both presentation modes in the relational task, the integrative pairs were still recalled significantly better than the unrelated ones.

As mentioned previously, the interaction between pair type and presentation format reached significance, however, break down analysis of the three way interaction indicated that this was attributable to the results within the item-specific conditions.

Integrative recall was analysed separately by running a 2 (task: item-specific vs relational) x 2 (presentation format: one at a time vs simultaneous) univariate ANOVA. The means are displayed in the figure below:

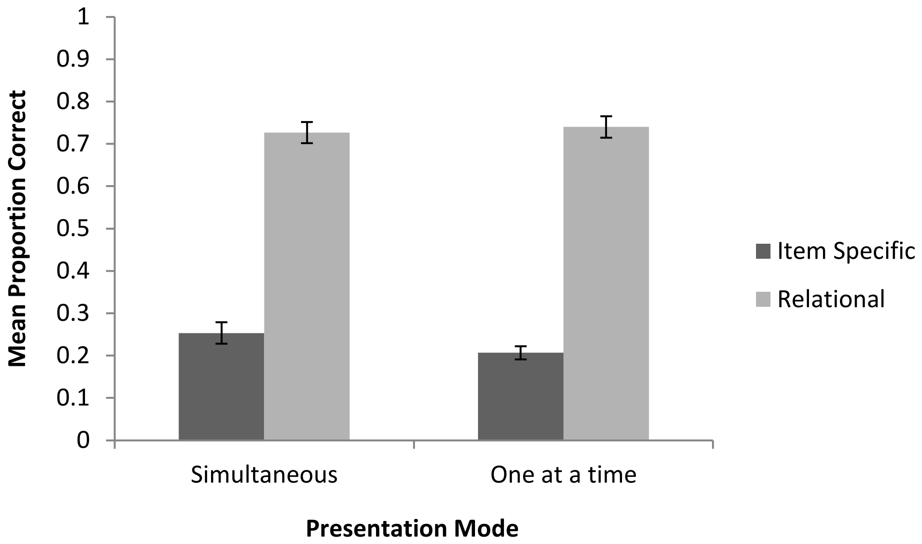

Fig 2.13 Proportion of integrative targets recalled across one at a time and simultaneous presentation in the item-specific and relational task. Error bars represent means to ±1 standard error.

It seems that task type is not differentially affected by whether the words of an integrative pair are presented simultaneously or one at a time. This was confirmed by the ANOVA as there was no significant interaction between task and presentation ($F(1, 56) = 1.673$, $MSE = .013$, $p = .201$).

Unrelated recall was also analysed separately in the same way as above. The means are displayed in the figure below:

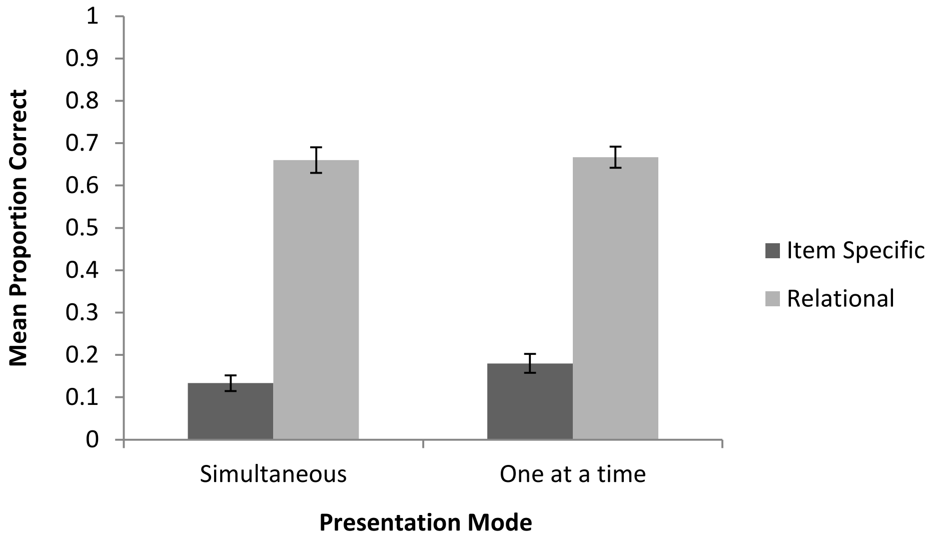

Fig 2.14 Proportion of unrelated targets recalled across one at a time and simultaneous presentation in the item-specific and relational task. Error bars represent means to ±1 standard error.

It appears that presentation format does not have a differential effect on unrelated recall in the item-specific and relational task This was confirmed by the univariate ANOVA as there was no significant interaction between task and presentation format ($F (1, 56) = .663$, $MSE = .006$, $p = .419$). Similar results were obtained with the older adults as the younger adults; as anticipated, the addition of a varying presentation format together with a more elaborative task was successful in removing the integrative advantage in the item-specific task for the older adults. No significant difference in recall was documented between integrative and unrelated pairs in the item-specific task when the words of each pair were presented one at a time. Focusing on item-specific properties of the integrative pairs when the words were presented one at a time prevented older adults from successfully integrating the pairs together and benefitting from their advantageous property. This suggests that the individual words making up the integrative pair must be encountered at the same time in order for appropriate relational processing to take place and stresses the importance of engaging in successful relational processing of the integrative pairs for their advantage to manifest itself.

A significant difference in recall between the integrative and unrelated pairs was obtained in the item-specific task when items were presented simultaneously, implying that the integrative advantage may have been partly due to fact that the integrative words appeared together; seeing the integrative words side by side most likely led to uncontrollable relational processing of the integrative words, even in the item-specific task.

Overall then, presentation format appears to have had a similar effect on both older and younger adults' recall of the integrative and unrelated pairs in the item-specific task. We now turn to an overall analysis comparing the performance of older and younger adults. It was predicted that there would be an overall age effect with the younger adults performing better than the older adults. In addition, it was thought that explicitly asking participants to engage in a relational processing task with the unrelated pairs would yield a smaller age difference than would appear in the item-specific task.

2.5.2.3 Combined analysis of younger and older adults

Data from both Experiments 3a and 3b were submitted to 2 (age: old, young) x 2 (pair type: integrative, unrelated) x 2 (task: relational, item-specific) x 2 (presentation: simultaneous, one at a time) repeated measures ANOVA. The means are illustrated in the following figures:

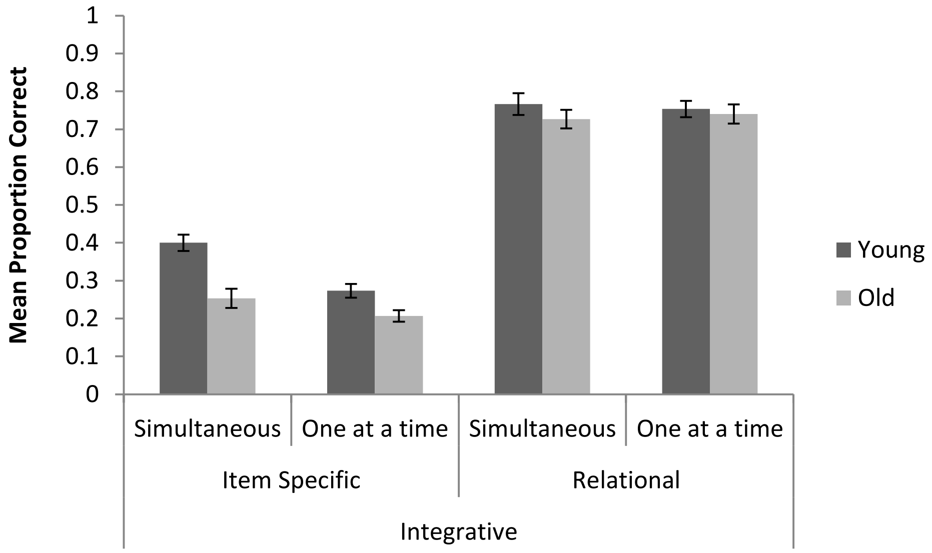

Fig 2.15 Proportion of integrative targets recalled across both age groups with simultaneous and one at a time presentation in both tasks. Error bars represent means to ±1 standard error.

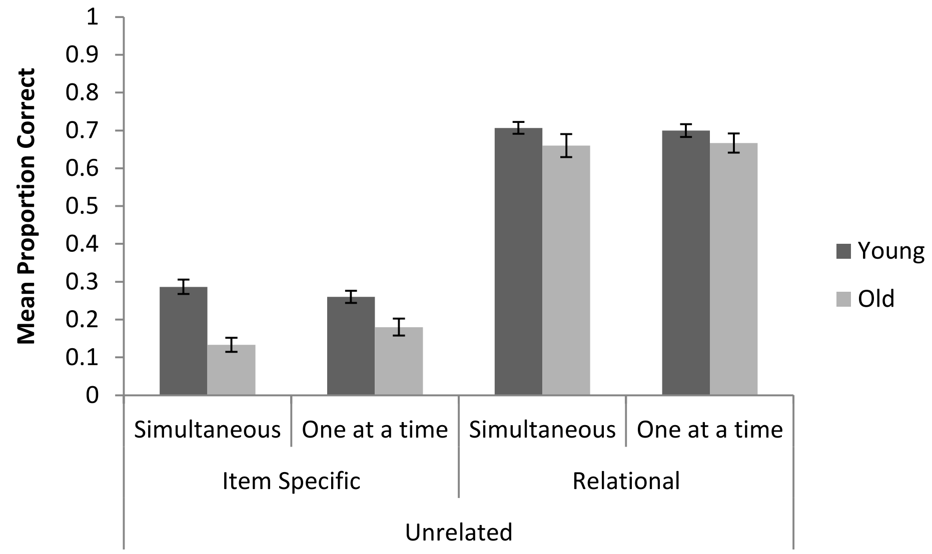

Fig 2.16 Proportion of unrelated targets recalled across both age groups with simultaneous and one at a time presentation in both tasks. Error bars represent means to ±1 standard error.

As anticipated, the typical age effect was replicated, with the younger adults performing better than the older adults (F (1, 112) = 26.373, MSE = .315, p<.001). The only interaction with age which reached significance was with task (F (1, 112) = 7.697, MSE = .092, p = .006). In order to break down this interaction, a new variable was computed (recall) which took the average of the integrative and unrelated recall per participant. The means are displayed in the figure below:

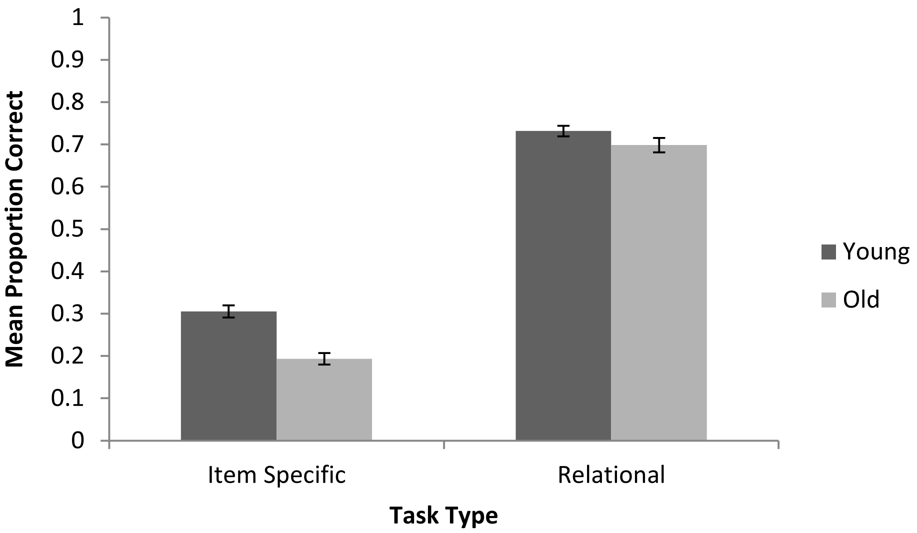

Fig 2.17 Proportion of targets recalled across both age groups in the item-specific and relational task. Error bars represent means to ±1 standard error.

The data was broken down by task, and an independent t-test was conducted on recall data with age (young vs old) as the factor. This revealed a significant effect of age in the item-specific task (t (58) = 5.687, p<.001), but not in the relational task (t (58) = 1.595, p = .058). The age difference was much larger in the item-specific task (difference of .12) than in the relational task (difference of .03) which suggests that the older adults were able to benefit more than the younger adults from the relational task – their performance increased from .19 in the item-specific task to .70 in the relational task, whereas the younger adults performance increased in a smaller magnitude from .31 in the item-specific task to .73 in the relational task.

The four way interaction between age, pair type, task and presentation format was not significant ($F(1, 112) = .015$, $p = .901$), nor was the interaction between age and pair type ($F(1, 112) = .757$, $MSE = .002$, $p = .386$), or age and presentation format ($F(1, 112) = 2.930$, $MSE = .035$, $p = .090$).

2.5.3 General discussion

The main aim of the current experiments was to see whether introducing item-specific processing in conjunction with one at a time presentation of the words within each pair would remove the integrative advantage. For both older and younger adults, integrative pairs behaved like unrelated ones when participants were instructed to process the words belonging in each pair in an item-specific way and when the words in each pair were encountered one at a time. The advantage was still apparent with simultaneous presentation in the item-specific task across both age groups justifying the adoption of one at a time presentation and including presentation format as an additional factor. The typical age effect was replicated with the younger adults recalling a greater proportion of items correctly than the older adults and smaller age differences were observed in recall of the unrelated and integrative pairs in the relational task than in the item-specific task. In addition, across both age groups, the three way interaction between task, pair type and presentation type was significant, suggesting smaller differences between integrative and unrelated pairs with one at a time presentation than with simultaneous presentation in the item specific task. In other words, presentation had more of an impact on recall of integrative and unrelated pairs in the item-specific task than in the relational task.

Previous research (Naveh-Benjamin, 2000) indicates unrelated word pairs produce larger age differences than related ones because of their lack of pre-existing associations. Age differences are minimized when stimuli enables participants to rely on long term previous knowledge and associations i.e. using semantically related words. Such findings are discovered involving study instructions to simply 'learn' the words. Therefore, when older adults are not given explicit instructions on which encoding strategy to use, age differences become more pronounced due to their reduced ability to spontaneously engage in appropriate encoding strategies. In the present experiment, it could be argued that the explicit item-specific sentence construction task instructions could have had a more detrimental effect on older adults' recall than instructions to simply learn the words as all of their available processing abilities (which are limited anyway) would have been focused on completing a task which would not have been beneficial to later recall. Based on this view, one could expect the older adults' performance to be particularly low on the item-specific task for both integrative and unrelated pairs, which it was. A future experiment could investigate this by including a control condition where participants are simply instructed to learn the words without explicit direction. It would be expected that the largest age difference would be obtained in the item-specific task, a smaller one in the control condition, and the smallest one in the relational condition.

The smallest age difference was demonstrated in recall of pairs in the relational task as explicit instructions to encode the words in a relational way would have substantially increased performance (Figures 2.15 and 2.16). Due to the older adults' significantly poor performance of the unrelated pairs in the item-specific task, they benefitted more from the relational processing of the unrelated items than the younger adults. This coincides with the results from Experiment 2 which found the relational task had a greater impact on recall of the unrelated items for the elderly than it did for the young.

One noteworthy finding was that when integrative recall was analysed separately, there was a significant interaction between task and presentation for the younger adults but not for the older ones. In the item-specific task, the words within each integrative pair encountered simultaneously were recalled significantly better than those that appeared one at a time for the young but not for the old. In other words, the younger adults were able to benefit from simultaneous presentation of the integrative pairs in the item-specific task whereas the elderly were not able to benefit. What explanation could there be for this simultaneous advantage of the integrative pairs for the younger adults? One possibility is that as the item-specific task was more elaborately demanding than the standard pleasantness rating task i.e. constructing a sentence requires more thought as well as processes involved to make a sentence which is grammatically correct, the older adults focused all of their available resources on performing the task, and because their resources are limited anyway, they would have been less aware of the fact that the words of a pair appearing simultaneously were integrative. As a consequence, their performance for integrative recall would not have changed significantly from one at a time presentation to simultaneous presentation. On the other hand, as the younger adults are likely to have greater resources available to them, they could have potentially identified an integrative pair more readily when it appeared simultaneously in conjunction with performing the item-specific sentence construction task, and were therefore able to benefit from their advantageous property. When the two words of an integrative pair are encountered simultaneously, the relational link becomes easier to formulate as the words are visualised together on the screen.

The relational task overall resulted in better memory performance than the item-specific task for both older and younger adults. The relational sentence construction task enabled pairs to be related together in a coherent and plausible way, and it could be argued that as the memory task was a cued recall one, it increased the encoding-retrieval match which is thought to be beneficial to memory performance (Tulving, 1983). Conditions at retrieval matched those at encoding which is why performance benefitted from the relational task more so than from the item-specific task. The encoding retrieval match states that performance is determined by the degree of overlap or match between the conditions during encoding and those during retrieval (Tulving, 1983). The greater the match or overlap between study and test, the better the performance. In terms of the present experiment, the relational task provided a greater match/overlap to the cued recall test as the task required them to use a relational technique to combine the words together. In order to perform well on a cued recall test one must have created and encoded a link between the cue and target, which the relational task would have provided. On the other hand, although there would have still been a match in the item-specific task as the same cues are present in the cued recall test, the degree of overlap would not have been as high as it was with the relational task, which more closely resembled the cued recall test. The individual sentence construction task did not enable relevant links to be formed and created, and as such did not provide as close a fit to the cued recall procedure as the relational task.

In summary, Experiments 3a and 3b were both successful in removing the integrative advantage in the item-specific task when design alterations were made, through using a more elaborative item-specific task in combination with one at a time presentation of the words in each pair. Both experiments suggest that the integrative advantage can only be removed by completely separating out the words belonging in the integrative pair and by performing an elaborately demanding item-specific task which is likely to require a significant amount of attentional resources. With simultaneous presentation the advantage was maintained in the item-specific task presumably because participants were able to notice that the words of an integrative pair appearing at the same time could be integrated relatively easily and in a way which made sense, and would have engaged in relational processing; this would have facilitated recall relative to unrelated pairs which did not possess any integrative link. Therefore, these experiments demonstrate that relational processing is partly responsible for the integrative advantage as complete prevention (by inducing an elaborative item-specific task together with completely destroying the relational link through one at a time presentation) removed its superiority over the unrelated pairs. However, if relational processing were solely responsible for the integrative advantage then we might have expected performance of the unrelated pairs to be closer to that of the integrative pairs when relational processing was encouraged. As the advantage was still apparent in the relational task across both presentation formats and age groups, this possibly suggests that the integrative pairs possess some other beneficial quality apart from encouraging relational processing. Another approach is to consider the possibility that relational processing brought on through some other medium other than sentence construction, could perhaps make the unrelated pairs behave like the integrative ones, and effectively remove the integrative advantage in a relational task. Previous experiments placed the emphasis on trying to get the integrative pairs to behave as unrelated ones. In the next study, we attempted to improve the performance of the unrelated pairs in an effort to have them approach the retrieval rates of the integrative ones. In Experiment 4, older and younger adults were instructed to learn integrative and unrelated pairs using a rehearsal strategy or an interactive imagery strategy, the latter of which is generally considered as a form of relational processing.

Chapter Three: Assessing the impact of relational processing through interactive imagery

3.1 Experiment 4

3.2 Abstract

Integrative word pairs, where the two words can be linked together to form a coherent phrase i.e. 'horse doctor', are better recalled than unrelated pairs in a paired-associate cued recall task, with the older adults benefitting more than the younger adults from the integratability of the pairs. The present experiment sought to investigate the effects of interactive imagery on the recall of integrative and unrelated word pairs amongst older and younger adults. Participants completed a cued recall task with both unrelated and integrative pairs and were required to learn the word pairs in one of two ways. In the control condition, a rehearsal strategy was used whereby participants simply rehearsed the word pairs aloud; in the interactive imagery strategy, they were instructed to construct a visual image of the two words within each pair interacting together in some way. Learning was followed by a cued recall task where participants attempted to recall the second word of each pair after being provided with the first word as a cue. There was a greater age deficit in the recall of the unrelated pairs compared to the integrative pairs. The interaction between strategy type and pair type also reached significance, with smaller differences between integrative and unrelated pairs when the imagery strategy was adopted relative to the rehearsal strategy. The three-way interaction was significant indicating that the older adults benefited more than the younger adults from the integrative pairs in the imagery task. Moreover, no significant age differences were apparent in integrative recall using the imagery strategy, suggesting that integratability of stimuli, together with interactive imagery, are effective methods for reducing the age related associative deficit typically portrayed by the elderly.

3.3 Introduction

Many studies have documented a significant age decrement in recall performance on memory tests between young and older adults (Hoyer & Verhaeghen, 2006; Zacks, Hasher, & Li, 2000). Numerous explanations have been proposed, including the associative deficit hypothesis (ADH, Naveh-Benjamin, 2000) and the limited resources approach (Craik, 1979) both of which have been influential and are of particular interest here. According to the ADH, older adults' episodic memory difficulties stem from their inability to create and retrieve new associations between items (Addis, Giovanello & Schacter, 2014; Chalfonte & Johnson, 1996). Findings from the previous experiments conducted in the thesis all appear to support the ADH, with the biggest age differences being obtained in associative recall of unrelated word pairs. In addition, across all experiments, age differences were minimized when word pairs consisted of an integrative quality i.e. 'monkey-foot' presumably because such pairs enabled integrative links to be formed between them, essentially allowing the older adults to benefit from a form of relational processing. The aim of the current experiment was to investigate whether this integrative advantage was attributable to improved/supported relational processing by using an interactive imagery strategy which could support the relational processing of unrelated pairs and hence perhaps alleviate the associative memory problems exhibited by the elderly.

Interactive imagery has been shown to help older adults' associative memory. For example, Patterson and Hertzog (2010) taught older and younger adults interactive imagery as a method for learning word pairs, and item as well as associative recognition was tested. The question of interest was to see whether getting younger and older adults to focus on processing the individual words in each pair before engaging in associative encoding would have an impact on the age-related associative deficit. The control condition involved participants forming an interactive image for each pair, whereas the experimental condition involved participants forming a mental image for each word (so 2 images per pair) followed by forming an interactive image for the pair. One prediction was that the experimental manipulation would make each item in the pair more distinctive, which in turn could benefit item recognition more so than associative recognition, thereby increasing the magnitude of the associative deficit. Alternatively, forming a mental image for each word could enhance the quality of interactive imagery, therefore raising the associative memory performance of older adults. There was an overall age effect, with older adults showing poorer recognition memory than the younger adults. An associative recognition advantage was demonstrated for both age groups in the control condition, and was reduced in the experimental condition, where participants had to generate images of each word prior to generating an interactive image, suggesting that interactive imagery can reduce the age-related associative deficit and benefit older adults' memory performance. Regarding the experimental manipulation, it appeared that item-specific processing of the individual word in each pair prior to engaging in interactive imagery enhanced the distinctiveness of each word, which is why the advantage for associative recognition was reduced.

Research on noun pairs suggests that associative learning is best when participants generate a mediator linking the to-be-associated items. This mediator can be a verbal connection such as a sentence involving either nouns, or an interactive image of the nouns. A study by Dunlosky, Hertzog and Powell-Moman (2005) suggests that there is minimal support for age differences among adults regarding the quality of mediators used. Older and younger adults were required to use either an imagery or sentence generation strategy to associate the items within a paired associate learning paradigm. When encouraged to use these strategies, older adults were just as effective as younger adults at generating appropriate mediators, and equally benefitted from their use, implying that older adults are capable of using an imagery strategy to facilitate associative recognition. Cohn, Emrich and Moscovitch (2008) also suggested that older adults are similar to younger adults in terms of producing mediators at study. Participants were compared on associative memory measures, and it was found that older adults were able to utilize associative information to a similar extent as younger adults in order to improve their memory. Another study by Fox, Baldock, Freeman and Berry (2016) found that the ability to generate deep mediators such as imagery did not differ between older and younger adults. Moreover, such deep mediator generations were related with high hit rates for items and associates for both age groups. Therefore, it appears that older adults are capable benefitting from the use of appropriate mediators involving imagery when they are instructed to do so.

Kuhlmann and Touron (2012) investigated mediator-based strategy use in older and younger adults in source monitoring tasks. Participants were instructed to use interactive imagery to encode the word pairs. No age related differences were observed in terms of mediator-based strategy production and utilization and young and older adults' source memory was equally improved with imagery instructions. Taken together, all these findings suggest that using interactive imagery as a means of encoding word pairs in paired associate learning paradigms is a successful strategy which can facilitate recall for both older and younger adults, as well as being able to reduce the age-related associative deficit. One possible explanation for the benefits of using interactive imagery is that images aroused by verbal stimuli can be combined into complex images which are 'functionally unitary, integrated memory structures' (Begg, 1972, p.431). Within this integrated memory structure, the elements interact to form a meaningful figure/conceptual unit, and the integrated memory representation leads to enhancement of recall.

However, the limited resources view (Craik, 1979) suggests that older adults' episodic difficulties stem from the fact that they are less able than younger adults to effectively engage in successful encoding operations. This view would therefore argue that older adults are unable to benefit as well as younger adults from strategies believed to facilitate memory performance, such as imagery. Craik and Byrd (1982) suggested that substantial pressures on cognitive processing resources are placed through the spontaneous use of appropriate mnemonic strategies, and that aging may be characterized by a reduced ability to use those resources effectively. In addition, it is thought that older adults 'allocate these resources less efficiently than do younger people' (Dirkx & Craik, 1992, p.352). Research has shown that older adults generally use strategies to a lesser extent than younger adults do (Rogers, Hertzog & Fisk, 2000). Naveh-Benjamin (2000) demonstrated that the associative deficit portrayed by older adults became larger under intentional learning conditions compared to incidental learning conditions. This implies that even when older adults were instructed to employ strategies in order to maximise the possibilities of successful retrieval, they were employed less effectively than younger adults. In another experiment, Naveh-Benjamin, Brav and Levy (2007) presented older and younger adults with unrelated word pairs under instructions to a) learn the word pairs (intentional), or b) create a sentence at encoding, or c) construct a sentence during encoding and use the sentence generation activity to help guide their responses during retrieval. Memory was assessed via item and associative recognition tasks. Older adults showed the expected associative deficit under intentional learning conditions, however, the deficit decreased under instructions promoting the use of effective sentence mediators during encoding (condition b). The associative deficit decreased even further when participants were encouraged to use the sentence generation strategy during both encoding and retrieval. When asked afterwards about how they had encoded the pairs in the intentional learning condition, younger adults reported using interactive imagery and sentence generation 92% of the time whereas older adults reported using no such strategies. In fact, the older adults claimed to have used rehearsal (a relatively ineffective strategy for this task) 67% of the time, whilst younger adults reported that they had never used this procedure. These findings suggest that older adults engage in less spontaneous use of associative strategies than younger adults. However, they also demonstrate that when older adults are directed to employ appropriate learning strategies such as sentence generation, they are able to benefit from their use, and that such strategies can reduce the age-related associative deficit.

Dirkx and Craik (1992) investigated the effects of aging using concrete and abstract words. It was predicted that for younger adults, recall of concrete words would be superior to that of abstract words because of the greater potential of evoking an image associated with the concrete (high-imagery) words. Differing predictions were made concerning older adults; if they exhibited problems with self-initiated processing as anticipated, then it could be expected that they would portray greater difficulties with image generation in comparison to their younger counterparts, and would therefore show no advantage for concrete words over abstract ones. As expected, concrete words were better recalled than abstract words, and this advantage was higher for younger adults under explicit imagery instructions. Clearly the younger adults were able to successfully employ an imagery mnemonic which facilitated recall and were able to benefit more than the older adults from the image arousing concrete words. Regarding imagery, and why older adults may possibly struggle with its use, the 'mental-imagery strategy is cognitively more demanding because, unlike the rehearsal strategy, it requires the creation of a link between the word and the corresponding visual representation in memory….the success of its execution will thus be tightly linked to the availability of cognitive resources' (Uittenhove, Burger, Taconnat & Lemaire 2014, p.1). As older adults are believed to have limited cognitive resources available to them, it is no surprise that they would struggle more in comparison to their younger counterparts in tasks relying on the use of imagery. Tournier and Postal (2011) found that older adults used fewer imagery strategies than younger adults, and although they are capable of employing imagery strategies when instructed, they utilise them to a lesser extent than younger adults (Lemaire, Arnaud & Lecacheur, 2004; Mata, Schooler & Rieskamp, 2007).

In summary, findings regarding the effects of imagery on the age-related associative deficit older adults' recall appear to be mixed; some indicate similar improvements in memory performance as a consequence of using imagery for older adults as younger adults, whereas others suggest that older adults have limited processing resources available for engaging in imagery operations. With these findings in mind, one question we can ask is whether using interactive imagery can benefit the recall of pairs which have no pre-existing association to each other and which are therefore unrelated. Presumably, producing an interactive image for an unrelated pair requires extra cognitive effort as previous knowledge regarding word associations cannot be called upon to aid with the process of generation. Concerning older adults, research has suggested that they suffer from an associative deficit, and that they have difficulties binding together different elements of an episode into a cohesive unit (Naveh-Benjamin, 2000), but that they are capable of using an imagery strategy as effectively as younger adults when instructed to do so (Cohn, Emrich & Moscovitch, 2008; Dunlosky, Hertzog & Powell-Moman, 2005; Patterson & Hertzog, 2010). On the other hand, research has also indicated that older adults engage in less spontaneous use of effective mediators during study, so it is reasonable to believe that older adults are less likely to spontaneously employ imagery-based processes. Based on these findings, it could be expected that older adults would exhibit an associative deficit under rehearsal instructions for studying unrelated pairs (because of their difficulty forming new associations and their reduced ability to spontaneously employ appropriate strategies) and that this deficit would be less pronounced under instructions to adopt an interactive imagery strategy. However, in line with the limited resources approach (Craik, 1979) it could also be expected that explicitly asking older adults to adopt an interactive imagery strategy with the unrelated pairs will have little benefit because of the effortful cognitive resources required to effectively process the pairs, which is limited in older adults. Therefore, differing predictions can be made concerning the memory performance of older adults when they are instructed to use an interactive imagery strategy on unrelated pairs.

Let us consider the integrative pairs; their integrative quality means that a strategy requiring participants to use imagery to make pairs interact is based upon the fact that the words of each pair are successfully *integrated* together and are hence *interactive*. As integrative pairs already possess this integrative quality, an interactive imagery strategy only serves to reinforce their beneficial advantage. Presumably, engaging in interactive imagery with the unrelated pairs means that the pairs have to be integrated in some way in order for them to interact. Therefore, it can be expected that recall of unrelated pairs using an interactive imagery strategy leads to the unrelated pairs acting as integrative pairs, and so will enhance their performance relative to a rehearsal condition.

It was predicted that using interactive imagery would benefit the older adults' performance with the unrelated pairs more than the younger adults, and that the biggest age difference would be observed in the rehearsal of unrelated pairs because of older adults' difficulty in forming new associations. An alternative prediction based on Craik (1979) is that older adults will show little improvement from using a rehearsal strategy to using an imagery strategy because they have fewer resources available for processing. A further prediction was that the interactive imagery strategy would not benefit the integrative pairs as much as the unrelated pairs because the integrative items already benefit from enhanced / obligatory relational processing.

3.4 Method

3.4.1 Participants

Twenty young adults (14 female) aged 18-34 and twenty healthy older adults (15 female) aged 65-88 years took part in the experiment. Young participants consisted mainly of undergraduates at City, University of London who participated in exchange for course credit/money. The others were enlisted via advertisements placed on websites and through a university designed system which contained details of experiments. Older participants were recruited by advertisements placed in the local Islington Gazette and through word of mouth; and were reimbursed for their travel expenses.

Both young and older participants completed the Wechsler Abbreviated Scale of Intelligence (Wechsler, 1999) as a brief measure of intelligence, and an independent t-test indicated that there was no significant difference in IQ between the age groups ($t(38) = .673$, $p = .505$). In addition, older adults were administered with the Mini Mental State Examination 2 (Folstein & Folstein 2012) to screen for cognitive impairment (Table 3.1). They also completed the Geriatric Depression Scale as a measure of their depression levels. Finally, for all participants, information was collected concerning their occupation and education level.

Table 3.1 The mean age and scores from the WAIS, MMSE-2, and the GDS for younger and older adults. Standard deviations are indicated in parentheses.

	Age	WAIS	MMSE-2	GDS
Younger adults	21.2 (2.8)	109.3 (6.7)	na	na
Older adults	72.3 (5.6)	107.5 (6.6)	28.6 (0.9)	5.2 (1.1)

3.4.2 Materials

Some integrative and unrelated pairs from the previous study were used, and additional stimuli were constructed to equate the integrative and unrelated pairs on UK Google hits. The same selection procedure used in the previous experiment was adopted to select appropriate stimuli, with the exception that a bigger set of stimuli was chosen. Once a set of 60 integrative and 60 unrelated word pairs were finalised, a small sample of 20 students rated the integratability of the word pairs on a scale of 1 to 7 (1 = not integratable, 7= highly integratable) and a total of 50 integrative and 50 unrelated pairs were chosen. The chosen integrative word pairs all received high ratings for integratability (M = 5.9, SD = 0.72) and the chosen unrelated word pairs received low integratability ratings (M = 2.2, SD = 0.70). In addition, all the pairs used had no pre-existing association in accordance with the University South Florida Free Association Norms.

Measures of word frequency, length, imageability, familiarity, concreteness etc for the chosen stimuli were obtained from the MRC Psycholinguistic Database, and t-tests revealed that there were no significant differences in these variables between the integrative and unrelated word pairs (see Appendix). In addition, there was no significant difference in UK co-occurrence (t (78) = 1.731, p = .087) or in worldwide co-occurrence (t (78) = 1.787, p = .078) between the integrative and unrelated pairs.

3.4.3 Procedure

A 2 (pair type: integrative, unrelated) x 2 (strategy: rehearsal, imagery) x 2 (age: old, young) mixed design was used. Participants were aware that their memory was being assessed as the majority of imagery studies use an intentional learning procedure. Also, the effectiveness of strategy use was being investigated which meant that participants had to be aware of the upcoming memory test. Each participant was presented with 4 lists, 2 composed entirely of unrelated pairs, and 2 consisting solely of integrative pairs on the computer using the software Visual Basic. Word pairs were presented in lower case, in Arial font size 14. For each pair type, one list required participants to use a rehearsal technique in order to remember the words, by verbally repeating each pair as many times as they wanted. The other required them to use an imagery strategy by constructing a visual image of the two words in each pair interacting together in some way. As the possibilities of contamination would have been present if the imagery strategy was conducted first (participants would have been more likely to use an imagery technique in the rehearsal condition if it was participated in first than if they participated in the rehearsal condition first), the decision was made for the rehearsal strategy to always come first, before the imagery strategy. Each list contained 15 items, and pairs appeared on the screen simultaneously. The presentation rate of each pair for younger and older adults was 5 and 10 seconds respectively. A brief distractor task of counting backwards in threes from a specified number followed the presentation of each list, after which a paired associate memory task was administered. During this task, the left word of each pair was presented, with participants having to verbally recall the right word and type it on the computer. Presentation of the words in the memory task was randomized, and recall was self-paced, although participants were encouraged not to spend too long on recalling the corresponding word. The whole procedure was then repeated for the next list, until all 4 lists had been completed by each participant.

3.5 Results

The mean proportion of targets correctly recalled across younger and older adults in each condition was calculated and is displayed below.

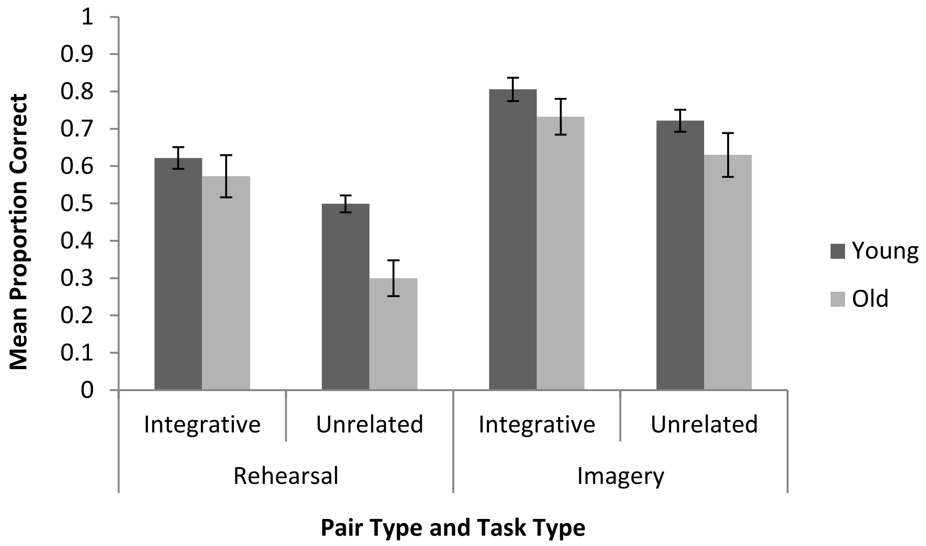

Fig 3.1 Proportion of integrative and unrelated targets recalled in the imagery and rehearsal task across older and younger adults. Error bars represent means to ±1 standard error.

Inspection of Figure 3.1 indicates that younger adults recalled more targets correctly compared to the older adults, as well better recall for the integrative pairs relative to the unrelated ones. In addition, memory seemed to be better following the imagery strategy compared to the rehearsal strategy. The age-related deficit appeared to be the largest with the unrelated pairs in the rehearsal condition, and the smallest with the integrative pairs in the rehearsal task.

Data was submitted to a 2 (age: old, young) x 2 (pair type: integrative, unrelated) x 2 (strategy: imagery, rehearsal) repeated measures ANOVA. The strategy called upon had a significant effect with the imagery condition producing better performance than the rehearsal condition (F (1,

39) = 85.933, MSE = .866, p<.001); integrative pairs were significantly better recalled than the unrelated pairs (F (1, 39) = 110.537, MSE = 2.054, p<.001) and younger adults also recalled more items correctly than older adults (F (1, 39) = 4.151, MSE = 4.151, p =.048). These main effects were qualified by a three-way interaction as well as by two two-way interactions. The interaction between strategy and pair type was significant, indicating smaller differences between integrative and unrelated pairs when the imagery strategy was adopted in comparison to when the rehearsal strategy was used (F (1, 39) = 11.711, MSE = .113, p<.001); age also interacted with pair type suggesting older adults benefit more from the integrative pairs than the younger adults (F (1, 39) = 7.197, MSE = .073, p = .011). Finally, the three-way interaction between strategy, pair type and age was also significant (F (1, 39) = 4.621, MSE = .045, p = .038). The interaction between strategy and age did not reach significance (F (1, 39) = .934, MSE = .017, p = .340).

To clarify the source of the three-way interaction, a 2 (strategy: rehearsal vs imagery) x 2 (pair type: unrelated vs integrative) repeated measures ANOVA was conducted for each age group separately. For the older adults, the interaction between pair type and strategy was significant (F (1, 19) = 9.636, MSE = .146, p = .006) but was not significant among the young (F (1, 19) = 1.819, MSE = .008, p = .192), this indicates that among the older adults, there was a greater improvement in performance from the rehearsal strategy to the imagery strategy with the unrelated pairs than with the integrative pairs. Performance for the unrelated pairs increased from 0.30 in rehearsal to 0.63 in imagery (increase of 0.33), whereas recall for integrative pairs increased from 0.57 in rehearsal to 0.73 in imagery (increase of 0.16). In contrast, the younger adults' performance improved in a similar magnitude from the rehearsal strategy to the imagery strategy for the unrelated pairs as it did for the integrative ones (see Figure 3.1).

To break down the significant pair type x strategy interaction for the older adults, a paired samples t-test was conducted and revealed that although the difference in recall between unrelated and integrative pairs was significant in both the rehearsal (t (19) = 5.649, p<.001) and imagery (t (19)

= 3.311, p = .002) conditions for the older adults, it was significantly greater in the rehearsal condition, which suggests that the imagery task benefitted the unrelated pairs more so than the integrative pairs among the older adults. The graph below has been reproduced for clarity.

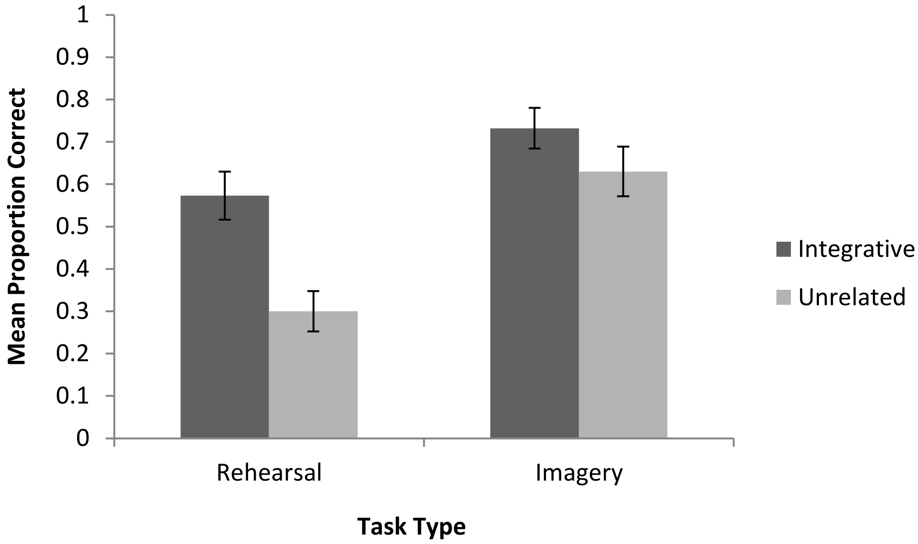

Fig 3.2 Proportion of unrelated and integrative targets recalled for the older adults in the rehearsal and imagery tasks. Error bars represent means to ±1 standard error.

As mentioned previously, the interaction between pair type and strategy reached significance, however, break down analysis of the three way interaction indicated that this was attributable to the results within the older adults. To understand the pair type x age interaction, two new variables were computed, 'integrative recall' and 'unrelated recall'. An independent t-test was then conducted with age (young vs old) as the grouping variable and integrative and unrelated recall as the dependent variables. This revealed a significant age difference for the unrelated pairs (t (39) = 2.846, p = .007) but not for the integrative ones (t (39) = 1.114, p = .272). Figure 3.3 shows the mean proportion of integrative and unrelated targets correctly recalled for both age groups and we can see that the older adults benefitted more than the younger adults from the integrative pairs.

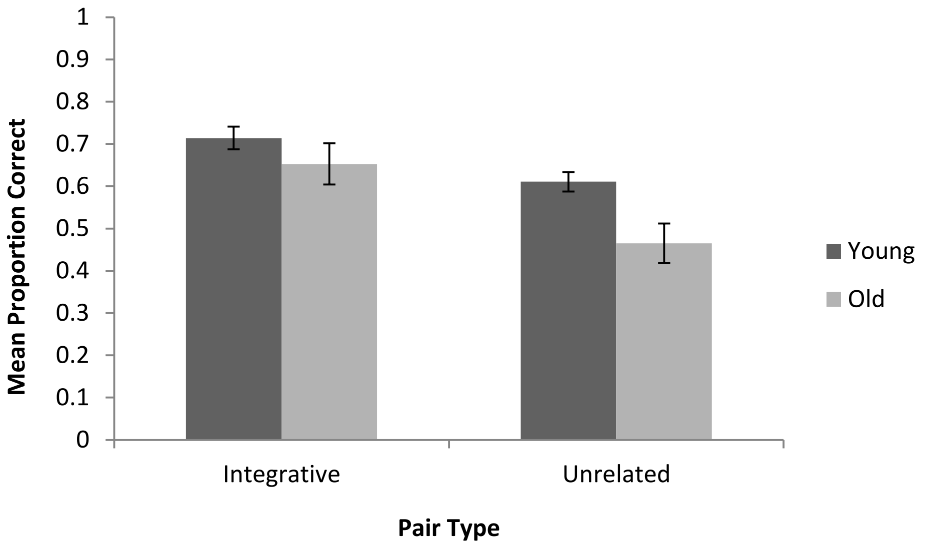

Fig 3.3 Proportion of unrelated and integrative targets recalled for both age groups. Error bars represent means to ±1 standard error.

To examine whether the age difference was significant in any of the conditions, an independent t-test was performed with age (young vs old) as the grouping variable factor and the four conditions (unrelated rehearsal, unrelated imagery, integrative rehearsal, integrative imagery) as the dependent variables. This revealed that the only significant age difference was with unrelated recall in the rehearsal task ($t(39) = 3.809$, $p<.001$). The age difference was not significant in the unrelated imagery condition ($t(39) = 1.419$, $p = .164$), the integrative rehearsal condition ($t(39) = .782$, $p = .439$) or the integrative imagery condition ($t(39) = 1.301$, $p = .201$, Figure 3.1).

To investigate whether the disproportionate advantage of the older adults relative to the younger adults with the integrative pairs compared to the unrelated pairs was significant within the rehearsal task, as well as in the imagery task, two separate 2 (age: young vs old) x 2 (pair type: integrative vs unrelated) repeated measures ANOVAs were conducted. For the rehearsal task, there was a main effect of pair type, with the integrative pairs being recalled significantly better than unrelated pairs ($F(1, 39) = 57.433$, $MSE = .803$, $p<.001$), and an age effect, with the younger adults recalling more targets correctly than the older adults (F (1, 39) = 5.828, MSE = .315, p = .021). In addition, the pair by age interaction reached significance (F (1, 39) = 8.264, MSE - .115, p = .007) indicating that the older adults benefitted more than the younger adults from the integrative pairs when the task involved rehearsal. An independent t-test demonstrated that there was a significant age difference on recall with the unrelated pairs (t (39) = 3.809, p<.001, but not with the integrative pairs (t (39) = .782, p = .439), suggesting that integrative pairs eliminate the age difference (figure 3.1).

In terms of the imagery task, whilst there was a main effect of pair type (F (1, 39) = 30.705, MSE = .177, p<.001) there was no age effect (F (1, 39) = 2.005, MSE = .165, p = .165) suggesting that recall did not differ significantly between older and younger adults in the imagery task. Moreover, there was no significant pair by age interaction (F (1, 39) = .294, MSE = .002, p = .591) implying that both age groups equally benefitted from the integrative pairs in the imagery task. Therefore, the disproportionate benefit older adults show compared to the younger adults with the integrative pairs in the rehearsal task becomes reduced when the task involves imagery; the older adults no longer benefit more than the younger adults from the integration between the pairs (refer to Figure 3.1).

As it was thought that the imagery task would equate performance of the unrelated and integrative pairs, such that the integrative advantage would be removed, paired samples t tests were performed comparing integrative imagery with unrelated imagery pairs across older and younger adults. This revealed significant differences in recall between integrative imagery and unrelated imagery pairs for younger adults (t (20) = 5.774, p<.001) and for older adults (t (19) = 3.311, p = .004). Therefore, the integrative pairs were recalled significantly better than the unrelated pairs in the imagery task, and the integrative advantage was maintained.

3.6 Discussion

Both age groups were able to benefit from the use of imagery for the unrelated pairs, although the older adults did exhibit a greater improvement, as their performance for the unrelated pairs increased more when imagery was used, in comparison to the younger adults. This suggests that the older adults are able to effectively engage in and employ useful processing strategies when they are required to do so. In accordance with the ADH, the largest age related difference was obtained with unrelated pairs in the rehearsal condition, demonstrating older adults' associative deficit. The age related difference for the unrelated pairs became considerably lower in the imagery condition indicating that the older adults benefitted the most from imagery instructions with the unrelated pairs. Therefore, interactive imagery was successful in reducing the disproportionate associative deficit older adults typically show with the unrelated pairs. It appears that engaging in processes which integrate pairs together, as well as imagining the resulting image, can have a positive impact on recall for pairs which previously had no semantic connection or association to each other. Thus results do not support Craik's (1979) limited resources view as this would have predicted little improvement in older adults' memory performance from using the imagery strategy on the unrelated pairs due to the fewer processing resources they had available to them; such limited resources would have made the ability to engage in self-initiated processing difficult. Another finding was that the disproportionate advantage older adults have relative to the younger adults with the integrative pairs was maintained in the rehearsal task, but became reduced in the imagery task, to the extent that both older and younger adults equally benefitted from the integration between the pairs when the task involved imagery. A possible reason is that the imagery task was very successful in improving the performance of the older adults with the unrelated pairs, such that they benefitted more than the younger adults with the imagery task for the unrelated pairs (because of their associative deficit). As a result of this substantial increase in performance from unrelated rehearsal to unrelated imagery, gains in recall would have not been disproportionally better than the younger adults from unrelated to integrative pairs in the imagery task.

As anticipated, the biggest age difference was observed in recall of the unrelated pairs in the rehearsal condition, thus demonstrating the associative deficit of older adults, and their difficulty forming new associations (Naveh-Benjamin, 2000). The fact that the older adults benefitted more from the imagery strategy in recall of the unrelated pairs suggests that their performance was initially lower with these pairs under rehearsal strategies. Research indicates that the elderly are less likely to use appropriate processing strategies in comparison to their younger counterparts (Naveh-Benjamin, 2000; Naveh-Benjamin et al., 2007; Rogers et al., 2000). The general consensus is that older adults engage in less spontaneous use of associative strategies, and as a consequence their performance deteriorates when asked to recall associative information. Because of this, they demonstrate the typical associative deficit. However, when older adults are explicitly directed to employ appropriate learning strategies, they show improvements in performance and are able to benefit from strategy use. Naveh-Benjamin, Brav and Levy (2007) found that older adults showed the expected associative deficit under instructions to learn a list of unrelated word pairs, but this deficit became reduced under instructions to create a sentence linking the two words together. Clearly, the elderly can utilise effective learning strategies when they are instructed to do so. Another point worth mentioning is that when participants were asked in the learning condition which strategy they had used, the younger adults reported using interactive imagery and sentence generation 92% of the time, whilst the older adults reported using no such strategy, instead opting to use rehearsal 67% of the time. Therefore, older adults engage in less spontaneous use of associative strategies than younger adults, unless they are explicitly directed to do so. The imagery task in the present experiment directed the older adults to employ appropriate associative processes and strategies.

Previous research indicates that whilst the older adults are able to benefit from learning strategies when they are explicitly told to use them, they struggle with certain components and processes involved in imagery, namely image generation (Craik & Dirkx, 1992; Dior & Kosslyn, 1994). Dirkx and Craik (1992) investigated the effects of using concrete and abstract words on recall of older and younger adults. It was thought that among the younger adults, recall of concrete words would be superior to that of abstract words due to the greater potential of evoking an image associated with the concrete words. In terms of the older adults, it was predicted that they would show no advantage for concrete over abstract words due to their difficulties with self-initiated processing and image generation (Dior & Kosslyn, 1994). In accordance with these predictions, the advantage was higher for the younger adults than the older adults. Based on this finding and in terms of the present experiment, it could be expected that the younger adults would show a greater advantage for the integrative over the unrelated pairs in the imagery condition in comparison to the elderly. Due to the integrative pairs being considerably easier to imagine because of their coherent interaction with each other than the unrelated pairs, and because of older adults' difficulties with image generation, we could predict a greater superiority of the integrative over the unrelated pairs for the younger adults than for the older adults in the imagery condition. However, inspection of the data indicates that there was no greater superiority of the integrative pairs in the imagery condition for the younger adults than the older ones. Results imply that the younger adults did not benefit more with the imagery task when recalling the integrative pairs and suggests that the older adults were able to equally benefit from generating interactive images of the integrative pairs as the younger adults.

Therefore, the results suggest that the elderly can use imagery as an effective learning strategy to facilitate associative recall and supports previous findings (Cohn et al., 2008; Dunlosky et al., 2005; Kuhlmann & Touron, 2012; Patterson & Hertzog, 2010). Taken together, they indicate that using interactive imagery as a means of encoding word pairs in paired associate learning paradigms is a successful strategy which can facilitate recall for both older and younger adults. Images aroused by stimuli can be combined into complex images which are 'functionally unitary, integrated memory structures' (Begg, 1972, p.431). Within this integrated memory structure the elements interact with each other to form a meaningful figure/conceptual unit, and the integrated memory representation leads to enhancement of recall.

The limited resources viewpoint could have been investigated further by asking participants to describe the kind of strategy they were using in the learn condition (as in the Naveh-Benjamin et al., 2007 study), and seeing whether the older adults were less likely to spontaneously employ strategies other than rehearsal. Such a finding would have added strength to the notion that explicit strategy instructions are crucial in attempting to reduce the age differences in memory performance.

This experiment has demonstrated the importance of using interactive imagery as an effective strategy for linking items together, particularly those which are unrelated. However, one could argue that the benefit provided by the imagery task of the unrelated pairs could have been due to individual pictorial images being constructed per se rather than the fact that the images were interacting together in some way and being relationally processed. In other words, it is possible that during the imagery task, some participants first constructed individual images of each word and then formed an image of the words interacting together, in essence combining item-specific and relational processing. What would happen in terms of the age effect if participants were explicitly told to firstly form images of each word separately before relating them together? Research indicates that older adultd demonstrate an item-specific encoding bias and rely more on its use than on relational processing. Therefore, a reasonable prediction would be that when they are asked to combine both forms of processing for a later associative test, item-specific processing would dominate more so than the relational one, so older adults would not benefit as much as they would from the pure relational task. On the other hand, younger adults show no evidence of bias and so would benefit more so than the elderly from the combined task. A future experiment could assess this and test these predictions.

Interestingly, the integrative advantage was still present for both older and younger adults in the imagery task. This suggests that the integrative pairs not only encourage relational processing, but that some other factor may also contribute to the advantage they produce. According to Estes and Jones (2009) integrative pairs consist of individual words which, when combined together, 'create a unitary representation' (p. 112). Specifically, the first or former word (the modifier) designates a subclass of the latter or second word (the head noun), so that they both refer to a single entity. Therefore, in order for a word pair to be considered as integrative, it must involve sub-classification of some sort. For example, the word pair 'silver bracelet' can be considered as an integrative pair as the word 'silver' modifies and provides sub-classification of the head noun 'bracelet'; the bracelet is not just made of any material, but of silver metal. This sub-classification property of the integrative led us to the hypothesis that that integrative pairs are more distinctive than the general class involved (i.e. bracelets), as the first word *specifies* a subclass of the second word. So 'lemon cake' is a specific type of cake flavoured with lemon, and 'apple tree' is a specific type of tree bearing apples and so-on and so-forth. It could be argued that the unrelated pairs possess a specific quality too, for example, 'wolf cigar' can be thought of as a wolf with a specific type of smoking object, a cigar. However, what separates this unrelated pair from integrative ones is the plausibility component – it is less plausible for a wolf to be smoking a cigar, unless perhaps in a specialised setting. On the other hand, 'lemon cake' and 'apple tree' are both plausible and coherent; it is normal for a cake to have flavouring such as lemon just as it is normal for a tree to grow fruit. Therefore, what makes the integrative pairs different from the unrelated ones can be hypothesised to be this specificity coupled with a sense of plausibility.

3.6.1 The role assignment model of relational integration

The role assignment model of relational concepts holds promise as a model which suggests the processes involved in producing the integrative advantage, and was originally developed to explain the integrative priming effect observed by Estes and Jones (2009). Priming occurs when prior presentation of a word facilitates the recognition of a related target word e.g. the word 'judge' facilitating recognition of the target word 'jury', and is generally attributed to associative strength, similarity among semantic concepts or compound familiarity. Estes and Jones (2009) found a different type of priming existed which could not be explained by any of the aforementioned attributes, in particular this priming presented itself among concepts which were dissimilar, unassociated and unfamiliar e.g. ‘horse doctor’. Such pairs were integrative in that the prime word could easily be integrated with the target word, thereby creating a unitary representation. It was thought that integrative priming could be explained by the role assignment model of relational integration: the words within each pair must be seen to perform complementary roles i.e. the containment relation (‘shoe box’) involves complementary roles of contained and container. Establishing a likely relation between two concepts is not enough for relational integration; engaging in a role assignment process and allocating those concepts to complementary roles is deemed crucial (Estes, 2003; Jones & Love, 2007). For example, contemplate the compounds ’factory smoke’ and ’fruit tree’; both of these compounds entail a production relation, however, the producer role occurs as a modifier in the first instance and as a head in the second one. Therefore, deducing a relation that is appropriate is inadequate for complete comprehension; engaging in a process where decisions can be made concerning which roles are performed by which concepts is necessary and crucial. Mather, Jones and Estes (2014) proposed that the activation of complementary roles was an automatic and uncontrollable process; they conducted two experiments which suggested that integration between cue and target was out of participant’s strategic control. According to Mather et al. (2014), when the two words of an integrative pair can be seen to be performing complementary roles, the ‘search for a plausible relation between the [cue] and target is terminated quickly and [recall] is facilitated’ (p.66). However, if a plausible relation which integrates the cue and target is difficult, as in an unrelated pair, then recall is likely to be detrimentally affected. The uncontrollable aspect of the integrative advantage accords with previous research (Jones, 2013; Lerner et al., 2012; Masson, 1995) which showed that semantic features and associated concepts are activated automatically following word presentation. So ‘to the extent that those semantic features and associated concepts are sufficient to identify a word’s relational role(s), role activation would also occur automatically’ (Mather et al., 2014, p. 67).

According to Doumas, Hummel and Sandhofer (2008), semantic nodes are present for objects, as well as for the relational roles the objects satisfy. For example, the noun compound 'jungle snake' can be comprehended by deducing a location relation that involves the roles of locale and object. Integrative facilitation would present itself when both the cue and target word (e.g. 'jungle' and 'snake') are readily allocated to roles which are complementary in a semantic relation (i.e. locale and object). It is thought that the mechanisms responsible for role assignment can be facilitated by means of frequency and plausibility.

3.6.2 Frequency

In terms of frequency, noun concepts seem to activate the most frequent integrative relations that they are associated with (Jones, Estes & Marsh, 2008). For example, the word 'chocolate' frequently instantiates the composition relation (e.g. chocolate bar, chocolate cake, chocolate biscuit). Consequently, this association results in the faster comprehension of noun compounds when a frequent relation is instantiated for the given modifier (e.g. chocolate bar) than when an infrequent relation is instantiated (e.g. chocolate cupboard). Role typicality can also be considered as an alternative interpretation of this effect; nouns (e.g. chocolate) are linked to semantic roles that they frequently epitomize (i.e. composition) and understanding is made easier when the given noun can be seen to be performing the role which it is typical of (e.g. chocolate bar). According to this model, the activation of the complementary role by a given noun can either occur prospectively or retrospectively. Consider a cue-target pair, such as 'chocolate bar', in terms of prospective activation, the cue (chocolate) activates its typical role (composition) which activates its complementary role (object), which in turn activates a selection of typical options which can fill that role (e.g. bar, cake, biscuit etc). Encoding is strengthened when target words are presented which are typical of and fit the complementary role. Therefore, although the role assignment model was not originally applied to episodic memory, the prospective link activation offers a viable explanation as to how role assignment can help with memory at the point of retrieval. Activation could also occur retrospectively, where the cue activates its typical and complementary role and participants engage in a retrospective check, evaluating whether the target word could indeed realistically perform the specified complementary role (e.g. whether a bar can have a composition). Therefore, the retrospective and prospective interpretations of the role assignment model differ in terms of when the activation of the complementary role concept occurs. However, evidence suggests that the concept of role typicality is essential. For example, convicting judge is comprehended faster than convicted judge as judges more typically engage in the convictor role than the convictee role. Alternatively, convicted criminal is comprehended faster than convicting criminal as criminals are more typically convictees than convictors (Ferretti, Kuters & McRae, 2007).

3.6.3 Plausibility

An additional component which relates to the role assignment model is that of plausibility. If a retrospective check is indeed undertaken upon presentation of an integrative word pair, how is plausibility determined? How does one make a decision as to whether a given concept (e.g. bar) can plausibly perform a certain role (e.g. object)? Research by Wisniewski and Murphy (2005) found that the plausibility of an integrative noun compound's referent predicted the amount of time needed to grasp the compound. However, it is not entirely clear what the definition of plausibility is and how it can be conceptualized (Costello & Keane, 2006). According to Connell and Keane (2006) something can be considered to be plausible if it makes sense and fits in with pre-existing knowledge. They argue that 'a highly plausible scenario is one that fits prior knowledge a) with many different sources of corroboration, b) without complex explanation, and c) with minimal conjecture' (p.117). A further issue which makes things more confusing is the fact that Wisniewski and Murphy (2005) discovered a strong positive correlation between plausibility and familiarity (>.90) suggesting that both of these concepts are very similar or at least highly related. However, they are entirely different constructs as familiarity concerns how frequently the referent of the combination actually occurs, whereas plausibility would refer to how easily the referent can be imagined. For example, 'library book' and ‘hospital book’ can be considered to be equal in terms of plausibility, yet for most people, the latter is less familiar than the former. Therefore, familiarity and plausibility is not the same thing, as it is possible to have a set of integrative pairs which are similar in plausibility, yet differ in terms of familiarity.

In summary then, it appears that the role assignment view of relational integration is an appropriate model through which mechanisms responsible for the integrative advantage could be identified. In addition, the concepts of plausibility, role typicality and familiarity are likely to be principal elements in governing whether integration occurs before the target is presented or after it is presented. Moreover, the model suggests that integrative pairs should be viewed as involving long term/pre-existing knowledge; in order to successfully integrate a pair together, one must possess knowledge of the fact that the words *can* be integrated together and that they make coherent sense when combined. With integrative pairs, people are able to formulate concepts which are consistent with knowledge acquired about the world, facilitating relational processing – or providing the relational framework which makes them more easily encoded and retrieved than the unrelated pairs.

If this is an appropriate depiction, it predicts that role assignment is central to the memorability of integrative pairs; if role assignment was made less useful, the prediction would then be that the integrative advantage would be proportionally reduced. One way in which this prediction could be tested is by using pairs where the same role assignment relation (e.g., made of) exists between the two words of a pair among all the pairs within the list. The reasoning is that if all the pairs call upon the same role assignment, it could potentially reduce the usefulness of the specific type of relationship, which the integrative pairs are known to promote. Previous studies (Badham et al., 2012; Estes & Jones, 2009) have presented integrative pairs where each relationship within the list is different e.g. made of, part of, located on etc., therefore no study involving integrative pairs has investigated this idea of sharing the relational roles within a list and making them potentially less useful. Experiment 5 tested this main prediction in the context of a recall and recognition task and sought to investigate plausibility and specificity of the integrative pairs.

Chapter Four: Overloading the role assignment of relational concepts and making it less unique: The impact of shared relational roles on the magnitude of the integrative advantage assessed via recall and recognition

4.1 Experiment 5

4.2 Abstract

Inter-list relations were manipulated with integrative and unrelated pairs across older and younger adults in an attempt to understand the mechanisms responsible for the superiority of integrative over unrelated pairs. The role assignment model of relational integration suggests that the individual words within integrative pairs must be seen to be performing complementary roles, each of which is distinct and specific. The aim of the present experiment was to see what would happen to the integrative advantage when such relational roles were made less distinct, and were shared within a list. Older and younger adults were presented with integrative and unrelated pairs, with some lists consisting of shared relations e.g. 'dog nose', 'cat head', 'donkey face' and others consisting of unique relations e.g. 'hospital floor', 'fireplace shop' and 'copper jug'. Cued recall as well as recognition was assessed, and it was revealed that the shared relationship had a greater detrimental effect on recall of integrative pairs relative to unrelated pairs, particularly more so among the older adults than the younger ones. In addition, the older adults exhibited significantly more false alarms to recombined pairs than the younger adults, presumably because of their increased reliance on familiarity and plausibility rather than on recollection. It appears that specificity, as well as the ability to perform plausible complementary roles, are the mechanisms through which the integrative advantage manifests itself.

4.3 Introduction

Research suggests that the episodic memory performance of older adults is characterized by deficits, especially on tasks requiring them to form new associations between previously unrelated items (Chalfonte & Johnson, 1996; Naveh-Benjamin, 2000). The associative deficit hypothesis

(Naveh-Benjamin, 2000) provides a possible explanation as to why older adults' memory is subject to decline by proposing that their difficulties stem from an inability to encode and retrieve new associations between items. Previous experiments conducted in the thesis so far demonstrate that this age-related associative deficit can be reduced by the presentation of integrative pairs, which have no prior association between them. In order for a pair to be considered integrative, the two words belonging in the pair must join together to make coherent sense, and the first word (the modifier) should specify a subclass of the second word (the head) such that they jointly refer to a single entity i.e. 'lemon cake'. Across previous experiments, an integrative advantage was found whereby integrative pairs were recalled better than unrelated pairs across older and younger adults. In particular, integrative pairs were found to reduce the age-related associative deficit, whereas such a deficit was still apparent for the unrelated pairs. One explanation for the possible benefits of the integrative pairs is that they promoted relational processing, which had a positive impact on later paired associate recall – conditions at encoding and retrieval would have matched as encoding the integrative pairs would have brought on relational processing techniques, and a paired associate task would have required the pairs to have been related together. According to Estes and Jones (2009), one of the components believed to be important in the integrative advantage is the role of plausibility. In this context, plausibility 'reflects the ease with which one can imagine the referent of the combination' (Estes & Jones, 2009, p.125). In order for a pair to be classified as integrative, the two words must hence relate together in a plausible way. For example, 'monkey foot' is entirely plausible as we all know that a monkey is a specific category of living thing and as such possesses usual body parts (in this instance a foot). A 'monkey foot' can easily be imagined as a noun concept / single picture/image. On the other hand, consider an unrelated pair such as 'phone mirror'; such a pair could perhaps eventually lead to an image or concept, but its plausibility is reduced relative to the previous pair and it is not as easy to imagine and integrate the two components. Generally speaking, coherence amongst concepts is considered to be pivotal in deciding whether something is plausible or not. In other words, plausibility is present if an item or thing is conceptually consistent with pre-existing knowledge (Collins & Michalski, 1989). For example, ‘copper jug’ is a plausible pair as copper is a fairly common metal from which a jug could be made from. However, ‘cotton jug’ is a much less plausible concept as jugs are not usually made of cotton. Therefore, a plausible interpretation describes something which is coherent with the interpreter’s knowledge of the world, even though it may not have been encountered before – it is plausible, even if it is novel.

When a person is presented with an integrative pair, the very fact that the two words relationally combine together in a way which is consistent with prior knowledge produces its plausibility. One important aspect of integrative pairs is that any given pair can often support multiple interpretations, and it is up to the interpreter to decide which interpretation is the most plausible. Consider the integrative pair ‘horse doctor’. Such a pair can offer numerous interpretations and the ‘acceptability of such interpretations will vary according to the degree to which the properties they contain are consistent with previous knowledge (Costello & Keane, 2000, p.309). One interpretation is a doctor who treats horses and the second is a doctor who looks like a horse. A further interpretation is a horse that is also a doctor. For most people, the first interpretation is more plausible as it coincides more with what can happen in reality, whereas the latter two require a more specialized context where the doctor resembles a horse, or the horse resembles a doctor.

In essence, the suggestion is that integrative pairs differ from unrelated ones in terms of their plausibility; words which relationally combine together in a way that is conceptually consistent with prior knowledge and/or experience are considered to be integrative and hence plausible. Costello and Keane (2000) describe how plausibility is ‘determined relative to all the knowledge in the knowledge base’ (p.310) which means that it can be affected by concepts not specifically mentioned in the original combination. This is an interesting point as it introduces the possibility that the integrative advantage may actually be reduced in instances involving shared relationships. Would an integrative pair which was not presented during the study phase be falsely remembered as being presented because it had a plausible and similar relation (e.g. made of) as other previously presented integrative items? Elaboration of this point will be considered later once literature on cue overload has been discussed as it relates to this idea.

4.3.1 Cue overload

According to the role assignment model, another factor (apart from plausibility) believed to be important to integrative pairs is that of sub-classification. In order for a pair to be considered as integrative, it must involve a process of sub-classification in that the first item can be seen to *specify* a subclass of the second item. In other words, some form of specificity is involved. Integrative pairs can be thought of as relatively unique in that they encompass an entity which is specialized and specific relative to unrelated pairs. For example, 'monkey foot' is a specific kind of foot; it's not just any foot but one which belongs and is part of a monkey. Similarly, 'horse doctor' is a special kind of doctor for horses, and 'copper jug' is a specific jug made of copper, not anything else. In essence, this specificity is thought to contribute to the ease with which integrative pairs can be remembered; they refer to a specialized concept based on prior knowledge. However, imagine that this integrative relationship was no longer unique, but shared by a number of other to-be-remembered items, what would happen to the integrative advantage? How would the integrative advantage survive if the relationship between the two words within a pair was overloaded instead of unique?

Cue overload is a well-established phenomenon which insists that the ability to successfully retrieve a given target is determined by the number of potential targets subsumed under a retrieval cue; as the number of potential targets associated with the retrieval cue increases, retrieval performance decreases (Watkins & Watkins, 1975). In other words, 'the efficiency of a functional retrieval cue in affecting recall of an item declines as the number of items it subsumes increases' (Watkins & Watkins, 1975, pg. 443). A seminal experiment by Watkins and Watkins (1975) illustrated the impact of cue overload as they found that memory performance in the recall task when provided with the category name as a cue decreased as the number of lists belonging to a category increased.

Related to the cue overload effect is the fan effect (Anderson, 1974) where the probability of successful recall decreases as information about the particular concept increases; in other words, the greater the size of the concept (or cue's) 'fan' the worse the memory performance. The fan effect also insists that recall is more likely with a cue which evokes a smaller number of competing retrieval candidates than a cue which calls upon a bigger number of candidates. Anderson (1974) introduced a number of propositions to participants, which involved presenting people in certain locations (e.g. a policeman is in the park). Altogether, there were a total of four manipulations involving the location (e.g. park) and person (e.g. policeman); person once-location once, person once-location twice, person twice-location once and person twice-location twice. In a later recognition task, the propositions encountered in the study phase as well as lures (recombined propositions which hadn't been presented) were shown to participants with them having to indicate whether they were true or false. It was found that as the number of items concerning a specific location or person increased, so did the time taken to respond, as well as the number of errors. Therefore, this fan effect is similar to the principle of cue overload, because it relates to the influence of numerous retrieval candidates being subsumed under one cue; the greater the number of targets associated with a cue (hence the more overloaded the cue is) the less likely it will result in accurate recall.

According to Craik (1979), the levels of processing effect can also be explained by means of cue overload. Typical experiments on levels of processing indicate that deeper processing of information leads to better memory performance than shallow processing (Craik & Lockhart, 1972). Tasks involving rhyming are normally used for shallow processing conditions whereas tasks focusing on semantics are usually employed for deep processing conditions. Craik (1979) believed that this pattern of findings could be explained by the fact that deep encodings are less overloaded and therefore more unique and effective than shallow encodings. For example, a sentence or phrase which is meaningful is likely to create an encoding environment which is specific and unique in comparison to that of a rhyme, the latter of which is likely to be shared by multiple items within the experiment as well as outside it. Therefore, a reasonable assumption based on this view would be that if both types of processing were somehow equated in terms of their level of overload, then disappearance of the level of processing effect is likely to occur. This prediction was tested by Nelson and Brooks (1974) in which both shallow and deep cues had equal set sizes. Results from free recall indicated no level of processing effect, which was interpreted as demonstrating the influence of cue-overload and its contribution to deep vs shallow encodings.

Moscovitch and Craik (1976) investigated the effect of the type of retrieval cue (whether it was unique to or shared among targets) and depth of processing on cued recall. Participants were asked three encoding questions which measured different degrees of depth: 'Does it rhyme with…? Does it belong to this category…? Will it fit into the sentence…?' These encoding questions were shared between ten target words or were unique to one target word. If highly overloaded cues are indeed created by shallow encodings, then one would expect that additional manipulation of cue overload through the same encoding question being shared between ten targets shouldn't have an impact on cued recall performance. It was found that the cue overload manipulation had a much less effect on cued recall for the shallow processing conditions than on the deep processing conditions. The authors concluded the effectiveness of a retrieval cue is reinforced by deeper processing as it makes the cue less overloaded and hence more unique than shallow processing. However, the beneficial effects of deep processing are reduced with an increase in the number of targets associated with the cue, as this subsequently increases the load.

Overall then, it seems that cue overload plays an important part in memory performance. The more overloaded the cue is, the less specific and unique the cue-target relationship becomes as increasing the load also increases the amount of potential targets shared among that cue. The 'degree to which a cue uniquely identifies a target appears to be a determining factor of retrieval success: shared (or overloaded) cues lead to significantly lower recall performance, as they specify a target less precisely than unique cues' (Koutmeridou, 2013, p.33).

Experiments 3a and 3b indicated that an orienting task that encouraged item-specific processing was successful in abolishing the integrative advantage among both older and younger adults. Presumably, this occurred as participants were unable to engage in relational encodings, suggesting that the ability to effectively employ relational processing is pivotal in the recall of integrative pairs. In accordance with the role assignment model of relational integration, the specificity as well as the plausibility of the integrative pairs could be investigated as possible mechanisms through which the integrative advantage manifests itself. For example, the integrative pair 'camera spray' involves sub-classification and is specific and plausible - it is a particular spray used explicitly for a camera, not just any spray. Moreover, it is entirely plausible for a spray to exist which is tailored specifically for cameras. Therefore, upon presentation of the pair during the study phase, participants are able to recognise that the relationship between the two words is specific as well as plausible; the pair 'camera spray' can be comprehended by deducing a functional relationship that involves the roles of object and function. Integrative facilitation would occur when both the cue and target are readily allocated to roles which are complementary i.e., the spray provides a use and function for the camera. During recall, upon presentation of the first word as cue (i.e., camera), participants are able to use the cue to narrow down the number of possible targets by thinking of the role(s) that the first word would have been likely to instantiate. They are aware that the corresponding target was plausible and made sense, and that the cue specified a subclass of the target, thereby narrowing the field of possible targets and decreasing the size of the memory search set. On the other hand, consider an unrelated pair such as 'stick diamond'. First of all, during the study phase, it would be evident that the two words of this pair cannot be seen to be performing complementary roles; how could stick and diamond plausibly be related? During recall, specificity would not be able to help narrow down the number of target possibilities as the pairing of the words would not have been plausible in the first place. This increases the number of possibilities and the size of the likely alternatives, thus making it harder to select the correct and appropriate target. It is just as likely that the corresponding target paired with the word 'stick' could be any other precious stone, such as emerald, ruby or sapphire. Therefore, it seems that a combination of plausibility and cue specificity both play a necessary role in the successful recall of the integrative pairs. When a pair is encountered, a plausibility check could occur first i.e. does the pair make sense? If yes, then exploration of the specific type of relationship could then occur i.e. how are the words related together? It is then this specific relationship which helps to narrow down the number of potential targets in memory and which leads to the superior recall of the integrative over the unrelated pairs. If the relationship between the integrative pairs was made to be less specific within a list i.e. more overloaded, would the advantage be reduced in comparison to when the relationships between the integrative pairs were all unique within a list? This is precisely the aim of the present experiment, to see whether overloading the integrative cues would be harmful to memory performance. The idea is that participants will be presented with a list of integrative pairs all comprising of a shared relationship e.g. clothes and material. It is anticipated that cued recall for the integrative shared pairs will be subject to greater difficulties than the integrative specific ones, due to a greater number of plausible competing targets. In addition, a further prediction is that as cue specificity and plausibility are believed to be important to integrative pairs but not to unrelated ones, the cue overload manipulation will have a greater impact on performance between integrative shared and integrative unique pairs than on the unrelated shared and unrelated unique pairs. Furthermore, a recognition test will also be administered in order to assess the impact of recombined plausible pairs on memory. Before we talk about the predictions concerning recognition data, it is necessary to discuss the literature regarding ageing effects on recognition.

4.3.2 Aging and recognition

A well-documented finding is that in comparison to younger adults, older adults tend to place greater emphasis on gist, familiarity and plausibility than on explicit recollection or retrieval (Perfect & Schwartz, 2002). This is because older adults have difficulties recollecting details of the past in comparison to younger adults (Jacoby, 1999). Such difficulties are more pronounced in the recall of associative information, and have been referred to as the associative-deficit hypothesis (Naveh-Benjamin, 2000). In particular, older adults demonstrate much greater declines in memory performance when asked to recall associations between unrelated items compared to related ones (Naveh-Benjamin, 2000). It appears that older adults increasingly rely upon other components of memory like the semantic links shared between the studied items. Research has indicated that older adults are able to perform at a similar level to younger adults by using these aspects of memory (Kensinger & Schacter, 1999; Thomas & Sommers, 2005). Indeed, in his fourth experiment, Naveh-Benjamin (2000) showed that age differences in associative memory appeared to be removed when semantically related word pairs were studied, thereby suggesting older adults' reliance upon semantic associations in aiding the identification of studied word pairs. However, relying upon such characteristics of memory can lead to more errors in memory performance for the older adults compared to the younger ones. For example, Kensinger and Schacter (1999) found that, relative to younger adults, older adults recalled more critical items which were not initially presented yet which were semantically associated to the studied items. It seems that older adults tend to place a greater reliance on the overall characteristics of the studied items to inform their memory decisions and reliance on such global aspects of the studied environment both facilitates and hinders their memory performance' (Cooper & Odegard, 2012, p.29).

Cooper and Odegard (2012) were interested in whether older adults would be able to compensate for their recollection difficulties of the past by using plausibility. Generally, when making a decision to reject a potential memory candidate, it is considered to be implausible in that it does not match with the overall environment of the study phase. However, reliance upon the plausibility of a memory target which did occur in study can lead to the incorrect acceptance of plausible candidates which were not initially presented. Younger adults are able to use recollection of what happened to stop the false acceptance of these items (Odegard, Keen & Gama, 2008). On the other hand, older adults are less likely to recollect the past as successfully as younger adults so consequently are more likely to incorrectly accept non-presented plausible memory items. Half of the participants were presented with pairs which rhymed with each other, e.g. ‘band sand’, ‘hug rug’, ‘land hand’, ‘mug bug’ and the other half were presented with pairs from the same category e.g. ‘boat train’, ‘banana apple’. A recognition test was then administered containing some word pairs previously presented as well as other new pairs. Some of the new pairs were consistent with the appropriate rule (either rhyme or category) by being re-arranged i.e. ‘band hand’, ‘hug bug’, and some were inconsistent with the rule i.e. ‘hug sand’. Participants had to indicate whether the pairs had previously been presented. It was predicted that re-arranged pairs which were inconsistent would be equally rejected by both older and younger adults using plausibility. However, it was expected that the older adults would incorrectly accept a greater proportion of consistently re-arranged pairs because of their plausibility in comparison to younger adults, who would utilise recollection to reject some of the items. In addition to indicating whether items had previously been presented, participants were required to explain their reasons for making their memory judgements. Findings demonstrated that the older adults primarily relied upon plausibility, in comparison to the younger adults who relied upon recollection and plausibility. Another observation was that older adults’ primary reliance on plausibility led to a greater proportion of falsely recognised distractors which were consistent with the rule than younger adults. It seems that placing an emphasis on plausibility and on what makes sense can have negative effects on memory performance among the elderly.

Based upon the findings of this experiment, a recognition test was also given to participants in addition to cued recall. Adopting a recognition phase would enable us to investigate whether older adults would exhibit more false alarms to consistently re-arranged and consistent new pairs in comparison to the younger adults because of their greater reliance on plausibility. A further prediction in line with Cooper & Odegard’s (2012) findings is that both age groups will equally reject inconsistently re-arranged and inconsistent new pairs by means of plausibility and recollection.

In the present experiment, semantic category was used as a means of manipulating cue overload as well as plausibility. Both integrative and unrelated word pairs were presented to older and younger adults. Each pair type comprised two lists, one shared and one unique, thus making a total of four conditions: integrative-shared, integrative-unique, unrelated-shared and unrelated-unique. For the integrative-shared condition, all the pairs had the same relationship existing between them e.g. all clothes made of a certain material. Therefore, all the words on the left belonged to one semantic category (i.e. material) and all the words on the right belonged to another (i.e. clothes) but the relationship between them was integrative i.e. 'cotton socks'. In the integrative-unique condition, all the pairs had unique pairings and did not share the same relationship e.g. 'monkey foot' (partonomy), 'camera spray' (function) and were integrative. For the unrelated-shared condition, pairs had no relation to one another yet the words on the left belonged to one semantic category (i.e. flavouring) and the words on the right belonged to another category (i.e. carpenter's tool), so an example would be the pair 'salt hammer'. In the unrelated-unique condition, the words on the left belonged to different categories as did the words on the right, and there was no relation between the items e.g. 'wife bridge', 'wolf cigar'. In essence, the relations between the items in the list were being manipulated. Following the presentation of each list, a brief distractor task was presented, after which half the items were tested via cued recall and the other half tested through recognition. The order of the memory tests was counterbalanced after each list to avoid order effects i.e. recall then recognition for the first list, recognition then recall for the second and so forth.

It was predicted that for both age groups, items belonging in the shared conditions would be more difficult to recall than items belonging in the unique conditions, due to the shared items being highly overloaded and hence more difficult to retrieve. This difference was expected to be much more pronounced among the integrative pairs than the unrelated ones, as the integrative pairs were believed to promote specificity and uniqueness, thus making them highly sensitive to the cue overload manipulation. A further prediction based on the associative deficit hypothesis was that older adults would find it harder than their younger counterparts in recalling the unrelated items because of their difficulty forming new associations. In addition, with regards to the recognition data, it was anticipated that older adults would exhibit a greater proportion of false alarms to consistently re-arranged and new items than younger adults due to their difficulties recollecting past details and their reliance upon plausibility and gist like information.

4.4 Method

4.4.1 Participants

Twenty four young adults (16 female) aged 18-35 and twenty four healthy older adults (18 female) aged 65-89 years took part in the experiment. Young participants consisted mainly of undergraduates at City, University of London who participated in exchange for course credit/money. The others were enlisted through advertisements placed on websites as well as around the university, and word of mouth. Older participants were recruited by advertisements placed in the local Islington Gazette and through word of mouth; and were reimbursed for their travel expenses.

Both young and older participants completed the Wechsler Abbreviated Scale of Intelligence (Wechsler, 1999) as a brief measure of intelligence, and an independent t-test revealed no significant difference in IQ between both age groups ($t(46) = .485$, $p = .630$). In addition, older adults were administered with the Mini Mental State Examination 2 (Folstein & Folstein 2012) to screen for cognitive impairment (Table 4.1). They also completed the Geriatric Depression Scale as a measure of their depression levels. Finally, for all participants, information was collected concerning their occupation and education level.

Table 4.1 The mean age and scores from the WAIS, MMSE-2, and the GDS for younger and older adults. Standard deviations are indicated in parentheses.

	Age	WAIS	MMSE-2	GDS
Younger adults	20.4 (2.6)	107.2 (7.6)	na	na
Older adults	75.6 (4.4)	108.2 (8.1)	28.5 (1.1)	5.1 (1.7)

4.4.2 Materials

Some integrative and unrelated pairs from the previous study were used, making up the lists for the integrative unique and unrelated unique conditions. Additional stimuli were constructed to make up a set of 60 integrative unique pairs and 60 unrelated unique pairs. The same selection procedure used in the previous experiment was adopted to select appropriate stimuli. For the unrelated shared and integrative shared conditions, pairs were chosen from the Battig and Montague (1969) category norms to ensure that the shared relationship was operationalised as items belonging to the same category. Altogether, 10 categories were chosen for the integrative shared pairs making a total of 5 shared relationships which were integrative, as the left word belonged to one category and the right word belonged to another. For example, two of the categories selected for the integrative shared condition were 'type of material' and 'items of clothing'. So the left word would be 'cotton' and the right word would be 'sock'. Each category consisted of 15 words resulting in a total of 150 words (75 pairs) for the integrative shared condition. In addition, 10 different categories were used for the unrelated shared pairs resulting in a total of five shared relationships but of which were unrelated e.g. 'type of seasoning' on the left and 'type of flower' on the right i.e. 'pepper tulip'. Once the stimuli were chosen, a small sample of 22 students rated the integratability of the word pairs on a scale of 1 (not integratable) to 7 (highly integratable). Following this procedure, 60 pairs were selected for each of the four conditions (integrative-shared, integrative-unique, unrelated-shared and unrelated-unique). The chosen integrative word pairs all received high ratings for integratability (M = 5.8, SD = 0.72) and the chosen unrelated pairs received low integratability ratings (M = 2.1, SD = 0.56). Furthermore, all the pairs had no pre-existing association in accordance with the USFFA norms (Nelson, McEvoy & Schreiber, 1998).

Measures of word frequency, length, imageability, familiarity, etc. for the chosen stimuli were obtained from the MRC Psycholinguistic Database, and t-tests revealed that there were no significant differences in these variables between all four conditions (see Appendix). A univariate ANOVA revealed that local co-occurrence did vary significantly between the four pair types (F (3, 236) = 85.077, MSE = 57.133, p<.001). This proved extremely difficult to equate, particularly as the constraint of using categories as the shared relationship had to be adhered to, and all words had to come from the category norms. However, multiple comparisons demonstrated that in line with the previous experiments, local co-occurrence was equated between the integrative unique and the unrelated unique pairs as p = .223 (see the Appendix for a full description of all the multiple comparisons). The following table shows examples of pairs for each of the four conditions.

Table 4.2 Examples of integrative and unrelated pairs with shared and unique relationships

integrative shared	integrative unique	unrelated shared	unrelated unique
squirrel-nose	car-toy	rose-carrot	bottle-necklace
donkey-face	paper-bin	daisy-lettuce	mirror-video
dog-eyes	hospital-floor	daffodil-corn	brick-milk

4.4.3 Procedure

A 2 (pair type: integrative, unrelated) x 2 (relationship: shared, unique) x 2 (age: old, young) mixed design was adopted with pair type and relationship being manipulated within subjects. Each participant was presented with eight lists on the computer using the software Visual Basic, with two lists belonging to each condition and was instructed to learn the pairs for upcoming memory tests. Each list comprised of a total of 24 pairs, with pairs presented sequentially and in Arial font with a size of 14. Presentation rates were the same as those used by Naveh-Benjamin (2000). A rate of 5 seconds per pair was chosen for the younger adults to prevent ceiling effects and a rate of 10 seconds per pair was chosen for the older adults to prevent floor effects.

Following exposure to all 24 pairs, a brief distractor task was administered for two minutes with participants having to count backwards in threes aloud from a randomised number positioned on the centre of the screen to prevent rehearsal. After the distractor task, a cued recall procedure followed for half the studied items; the cue (1st word of each pair) was presented to the left of the screen centre, with participants being required to type the corresponding 2nd word in a space at the right of the screen centre. Immediately after the recall phase, a recognition test appeared, where a total of 18 pairs were tested; participants had to indicate whether each pair had been previously studied. Pairs were presented in the middle of the screen in Arial font with a size of 16. Participants pressed 'Y' on the keyboard for 'yes' and 'N' for 'no'. The response was self-paced with the next pair being presented only after a response had been made to the previous pair. Of the 18 pairs, 12 were constructed from the items within the original study list; these were the pairs that were studied but not tested in the recall phase. Out of those 12 pairs, six were original and six were recombined; a further six were new pairs. The procedure was then repeated for the next list, except that the order of the memory tests was counterbalanced, so for the second list, the recognition test preceded the recall one. This was to avoid the possibility order effects. As there were a total of four list types, the presentation order of the list type was also counterbalanced, resulting in a total of 24 possible combinations (4 x 3 x 2). In addition, as two lists were presented overall for each condition, the program randomly selected 24 pairs for the first list, and the remaining 24 for the second list. Recall that there was a total of 60 pairs per condition; the other 12 pairs were new ones for use during the recognition phase and so had not been presented to participants during the study phase. A further control was that each participant was presented with exactly the same stimuli, albeit in a different order/combination, reducing the likelihood of differences in stimuli being a potentially confounding variable.

For the shared conditions (integrative-shared and unrelated-shared), each list comprising of 24 pairs consisted of two shared relationships of the four categories. For example, 12 pairs could have the relationship ‘made of’ with type of material on the left and clothing on the right, and 12 could have the relationship ‘part of’ with animal on the left and body part on the right. So each shared list was composed of two subsets of relationships i.e. set A and set B. A constraint of this meant that during recall, where half of the items were presented, six of the left words from set A were chosen and six from set B were chosen. Moreover, for recognition, three of the original pairs from set A were presented, along with three recombined pairs for set A, and three original pairs from set B were selected, with three recombined set B pairs. Three new pairs consisting of the same relationship of set A were used and three new pairs with the same relationship as set B were used. Two subsets per list were used as it was thought that more than 12 items per relationship would overload the cue too much and make recall and recognition significantly harder.

4.5 Results

4.5.1 Recall

The mean proportion of targets correctly recalled during the paired associate test in each condition across both age groups is displayed in the figure below.

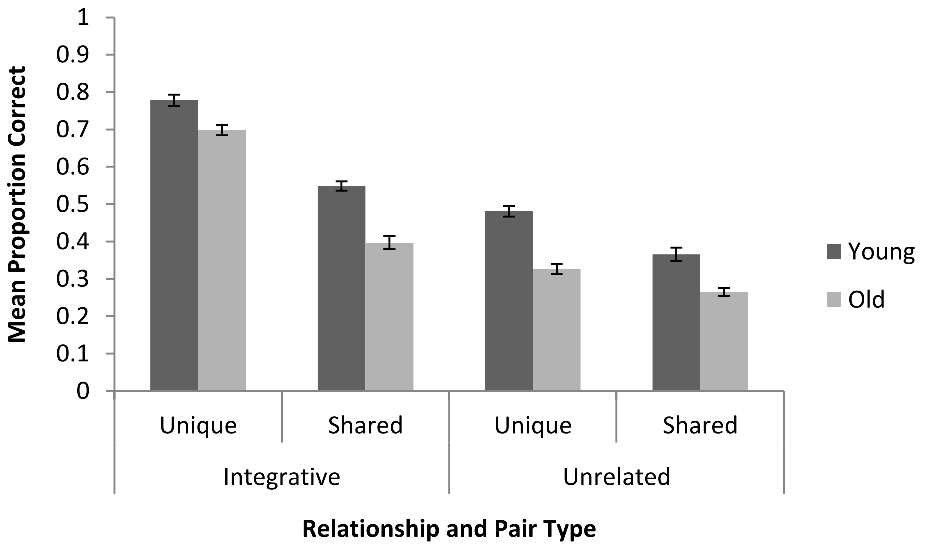

Fig 4.1 Proportion of integrative and unrelated targets recalled across both age groups in shared and unique relationships. Error bars represent means to ±1 standard error.

It appears that overall, recall for younger adults was greater than that of the older adults and was higher with integrative pairs relative to unrelated pairs. In addition, those pairs consisting of unique relationships seemed to be recalled better than those with shared relationships existing between them. Interestingly, the relationship manipulation appears to have had less of an effect on the unrelated pairs for older adults in comparison to all of the other conditions. Another observation is that type of relationship seemed to have more of a detrimental effect on the integrative pairs than on the unrelated ones across both older and younger adults. Data was submitted to a 2 (age: old, young) x 2 (pair type: integrative, unrelated) x 2 (relationship: shared, unique) repeated measures ANOVA. Relationship was significant with the unique condition producing better performance than the shared condition ($F (1, 46) = 325.915$, $MSE = 1.460$, $p<.001$) as well as pair type with the integrative pairs being better recalled than the unrelated pairs (F (1, 46) = 655.602, MSE = 2.955, p<.001). Age was also significant, with the younger adults recalling more items correctly than the older adults (F (1, 46) = 101.517, MSE =.682, p<.001). The interaction between pair type and age did not reach significance (F (1, 46) = .739, MSE = .003, p = .394), nor did the interaction between relationship and age (F (1, 46) = .030, MSE = .000, p = .864).

The three-way interaction between relationship, pair type and age was significant (F (1, 46) = 7.538, MSE = .040, p = .009), and was broken down to investigate whether the disproportionate advantage of the older adults relative to the younger adults with the integrative pairs compared to the unrelated pairs was significant with unique relationships, as well as with shared relationships. Two separate 2 (age: young vs old) x 2 (pair type: integrative vs unrelated) repeated measures ANOVAs were conducted, the first with unique relationships, and the second with shared relationships. For the unique relationship, there was a main effect of pair type, with the integrative pairs being recalled significantly better than unrelated pairs (F (1, 46) = 700.542, MSE = 2.680, p<.001), and an age effect, with the younger adults recalling more targets correctly than the older adults (F (1, 46) = 58.366, MSE = .331, p<.001). In addition, the pair by age interaction reached significance (F (1, 46) = 8.627, MSE - .033, p = .005) indicating that the older adults benefitted more than the younger adults from the integrative pairs when the relationships within the list were unique. An independent t-test revealed that the age difference was significant with the integrative unique pairs (t (46) = 4.005, p<.001) as well as with the unrelated unique pairs (t (46) = 7.840, p<.001), although it was significantly larger with the unrelated unique pairs, therefore reproducing prior findings.

Concerning the shared relationships, there were main effects of pair type (F (1, 46) = 106.048, MSE = .631, p<.001) and age (F (1, 46) = 63.532, MSE = .350, p<.001) suggesting that recall was greater with integrative relative to unrelated pairs, and that younger adults recalled more than the older adults. However, no significant pair by age interaction was apparent (F (1, 46) = 1.683, MSE

= .010, p = .201) implying that that both older and younger adults equally benefitted from the integrative pairs when the relationships were shared within the list. Therefore, the disproportionate benefit older adults show compared to the younger adults with the integrative pairs with unique relationships becomes reduced when the relationships are shared; the older adults no longer benefit more than the younger adults from the integration between the pairs (refer to Figure 4.1).

The interaction between relationship and pair type was significant (F (1, 46) = 67.512, MSE = .355, p<.001), indicating a greater effect of relationship type when the pairs were integrative than when they were unrelated. Figure 4.2 illustrates the means for integrative and unrelated pairs with shared and unique relationships.

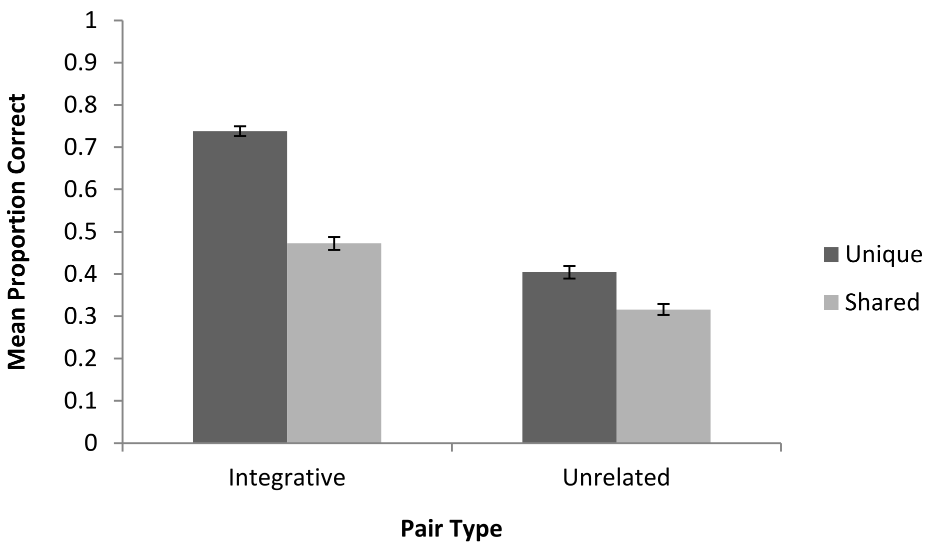

Fig 4.2 Proportion of integrative and unrelated targets recalled in shared and unique relationships. Error bars represent means to ±1 standard error.

Paired samples t-tests were conducted and revealed that the effect of relationship on recall was significant across both integrative (t (47) = 17.203, p<.001) and unrelated (t (47) = 6.194, p<.001) pairs. Therefore, it seems that the integrative pairs were more significantly affected than the unrelated pairs by the relationship manipulation.

To assess the impact of age on each of the four conditions (integrative-shared, integrative-unique, unrelated-shared, and unrelated-unique), an independent t-test was conducted with age (young vs old) as the grouping variable factor and revealed significant age differences across all 4 conditions (integrative-shared pairs $t(46) = 6.251$, $p<.001$, integrative-unique pairs $t(46) = 4.005$, $p<.001$, unrelated-shared pairs $t(46) = 4.763$, $p<.001$, and unrelated-unique pairs $t(46) = 7.840$, $p<.001$).

In accordance to previous studies conducted within the thesis, the age difference was the largest with respect to unrelated unique pairs (difference of 0.15), and was the smallest with integrative unique pairs (difference of 0.08). As it was anticipated that the introduction of a shared relationship would remove the integrative advantage, a paired samples t-test was conducted comparing integrative shared and unrelated unique pairs. This revealed that there were still significant differences in recall between the integrative shared and the unrelated unique pairs for the older adults ($t(23) = 3.663$, $p<.001$) and the younger adults ($t(23) = 4.291$, $p<.001$).

4.5.2 Recognition

Measures of proportions of hits and false alarms (FA) to recombined, as well as to new pairs, were computed for each participant and then averaged within each group and condition. In addition, corrected recognition scores for the average of recombined and new pairs were obtained by subtracting the proportion of FA from the proportion of hits. This was to assess participants' ability to discriminate between old and new paired items. Corrected recognition was computed for each participant and then averaged within each age group for each condition.

The two tables below indicate the mean proportions of hits, FA to recombined pairs, and FA to new pairs across older and younger adults for each condition.

Table 4.3 Proportions of hits, FA to recombined and FA to new pairs for older adults with integrative and unrelated pairs in shared and unique relationships

	Old			
	Integrative shared	Integrative unique	Unrelated shared	Unrelated unique
Hits	0.83 (.08)	0.88 (.08)	0.77 (.08)	0.79 (.08)
FA Recombined	0.57 (.07)	0.28 (.11)	0.60 (.08)	0.59 (.08)
FA New	0.24 (.07)	0.17 (.1)	0.27 (.06)	0.25 (.06)

Table 4.4 Proportions of hits, FA to recombined and FA to new pairs for younger adults with integrative and unrelated pairs in shared and unique relationships

	Young			
	Integrative shared	Integrative unique	Unrelated shared	Unrelated unique
Hits	0.87 (.07)	0.9 (.07)	0.80 (.07)	0.81 (.08)
FA Recombined	0.40 (.06)	0.2 (.09)	0.45 (.07)	0.35 (.07)
FA New	0.17 (.07)	0.1 (.08)	0.24 (.06)	0.21 (.05)

We can see that the proportion of hits did not appear to vary much between older and younger adults for each of the four conditions. Moreover, it seems that older adults in general exhibited more FA to recombined pairs than younger adults, particularly for the shared conditions. It also appears that for both age groups, there was a greater effect of the relationship manipulation on the proportion of FA to recombined pairs with the integrative pairs than with the unrelated pairs. In terms of FA to new pairs, older adults seem to demonstrate more in comparison to younger adults, and like the FA to recombined pairs, for both age groups there appears to be a greater impact of relationship on the proportion of FA to new pairs with the integrative pairs than with the unrelated pairs.

To assess participants' ability to discriminate between old and recombined/new paired items, corrected recognition (proportion of hits minus proportion of average FA) was computed for each participant and then averaged within each age group for each condition, with higher scores indicating good discrimination and hence more accurate recognition. The mean proportion of corrected recognition scores across all conditions is displayed in the figure below.

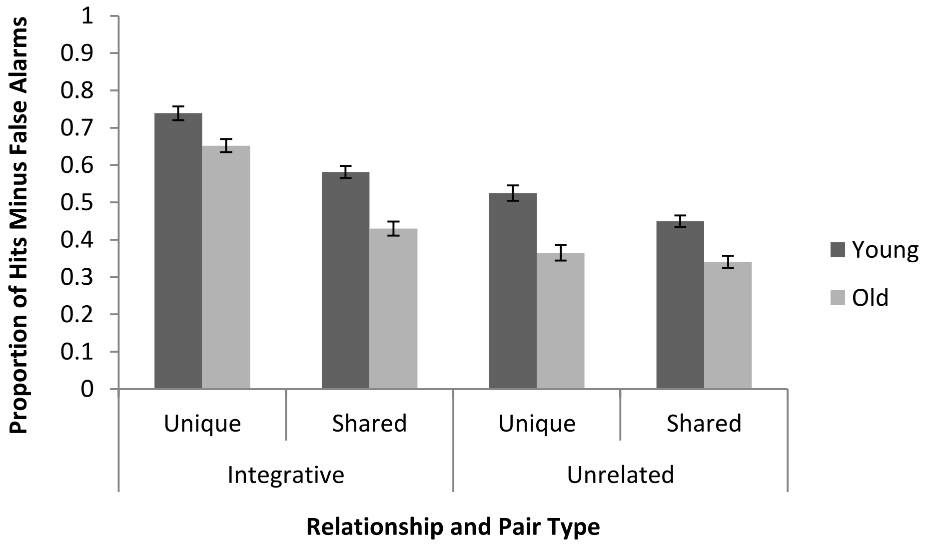

Fig 4.3 Proportion of hits minus average FA across older and younger adults with integrative and unrelated pairs in shared and unique relationships. Error bars represent means to ±1 standard error.

We can see that overall the younger adults displayed higher levels of recognition than the older adults, and that scores were higher with integrative relative to unrelated pairs. In addition, recognition seemed to be better with unique relationships compared to shared relationships. Furthermore, the age difference in recognition appeared to be the most pronounced with unrelated unique pairs than in any of the other conditions.

A mixed ANOVA revealed integrative pairs were recognised significantly greater than unrelated pairs (F (1, 46) = 225.977, MSE = 1.566, p<.001), and pairs with unique relationships were recognised better than those consisting of shared relationships (F (1, 46) = 101.670, MSE = .689, p<.001). The age effect was significant, with younger adults recognising more pairs than the older adults (F (1, 46) = 63.976, MSE = .773, p<.001). The interaction between relationship and age did not reach significance (F (1, 46) = .089, MSE = .001, p = .767) neither did the pair by age interaction (F (1, 46) = .412, MSE = .003, p = .524). However, the pair by relationship interaction was significant (F (1, 46) = 42.111, MSE = .234, p<.001).

The three-way interaction between pair type, relationship and age reached significance (F (1, 46) = 7.250, MSE = .040, p = .010), and break down analysis was performed with two 2 (pair type: integrative vs unrelated) x 2 (age: young vs old) repeated measures ANOVAs, the first with unique relationships, and the second with shared relationship. For the unique relationship, there was a main effect of pair type, with the integrative pairs being recognised significantly better than unrelated pairs (F (1, 46) = 198.124, MSE = 1.505, p<.001), and an age effect, with the younger adults recognising more pairs correctly than the older adults (F (1, 46) = 35.248, MSE = .365, p<.001). In addition, the pair by age interaction reached significance (F (1, 46) = 4.248, MSE = .032, p = .045) indicating that the older adults benefitted more than the younger adults from the integrative pairs when the relationships within the list were unique. An independent t-test revealed that the age difference was significant with the integrative unique pairs (t (46) = 3.422, p<.001) as well as with the unrelated unique pairs (t (46) = 5.473, p<.001), although it was significantly larger with the unrelated unique pairs.

With regards to the shared relationships, there were main effects of pair type (F (1, 46) = 60.342, MSE = .295, p<.001) and age (F (1, 46) = 48.051, MSE = .408, p<.001) suggesting that recognition was greater with integrative relative to unrelated pairs, and that younger adults recognised more pairs than the older adults. However, no significant pair by age interaction was apparent (F (1, 46) = 2.218, MSE = .011, p = .143) implying that that both older and younger adults equally benefitted from the integrative pairs when the relationships were shared within the list. Therefore, the disproportionate benefit older adults show compared to the younger adults with the integrative pairs with unique relationships becomes reduced when the relationships are shared; the older adults no longer benefit more than the younger adults from the integration between the pairs (refer to Figure 4.3).

An alternative way of decomposing the three-way interaction was performing paired samples t-tests to see whether relationship had a significant impact on recognition with the integrative and unrelated pairs for older and younger adults. Integrative-shared and integrative-unique, as well as unrelated-shared and unrelated-unique pairs were compared across both age groups separately. Regarding the younger adults, there was a significant effect of relationship on recognition for integrative pairs (t (23) = 6.866, p<.001), as well as for unrelated pairs (t (23) = 2.980, p = .007). On the other hand, for older adults, whilst relationship significantly affected recognition for integrative pairs (t (23) = 14.180, p<.001), it did not for the unrelated pairs (t (23) = .968, p = .343). Clearly, among the elderly, recognition was not significantly affected by whether the unrelated pair had a shared relationship or not.

As mentioned before, the pair by relationship interaction was significant (F (1, 46) = 42.111, MSE = .234, p<.001) implying that the unique relationship benefitted the integrative pairs more than the unrelated pairs. The figure below displays the means.

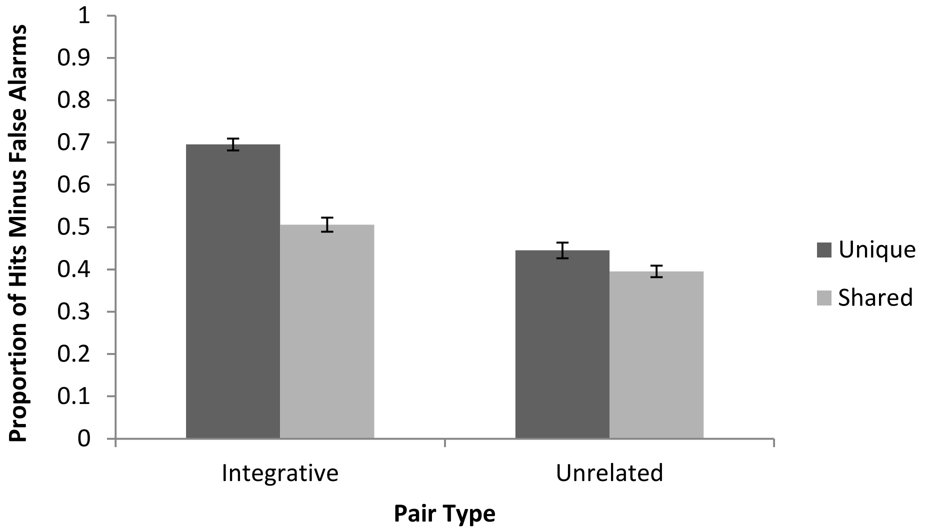

Fig 4.4 Proportion of hits minus average FA with integrative and unrelated pairs in shared and unique relationships. Error bars represent means to ±1 standard error.

Paired samples t-tests indicated a significant effect of relationship on recognition for integrative (t (47) = 13.066, p<.001), and unrelated pairs (t (47) = 2.759, p = .008), although relationship had a significantly greater impact on recognition for the integrative compared to the unrelated pairs.

To investigate whether there were any significant age differences in recognition for recombined pairs, an independent t-test was performed with age (young vs old) as the grouping variable and integrative-shared, integrative-unique, unrelated-shared and unrelated-unique as the dependent variables. There were significant age effects for integrative unique pairs (t (46) = 3.422, 11 p<.001) integrative shared pairs (t (46) = 6.130, p<.001) unrelated shared pairs (t (46) = 4.868, p<.001), and for unrelated unique pairs (t (46) = 5.473, p<.001). As anticipated, the largest age difference (0.26) was present for the unrelated shared pairs.

As it was thought that the addition of a shared relationship would equate performance of the integrative pairs to the unrelated ones, paired samples t-tests were conducted comparing integrative-shared with unrelated-unique pairs for younger and older adults. There were significant differences in recognition between integrative-shared and unrelated-unique pairs for the younger adults (t (23) = 2.165, p = .041) as well as for the older adults (t (23) = 2.658, p = .014). Therefore, the integrative advantage could not be removed when the relationship was shared between integrative pairs.

4.6 Discussion

The aim of the present experiment was to see whether making the relationship between the integrative pairs within a list shared would be harmful to memory performance, due to a greater number of plausible competing targets, and would remove the integrative advantage. Moreover, it was predicted that the shared relationship manipulation would have a greater impact on performance with the integrative pairs than with the unrelated pairs as specificity was believed to be an important component in the integrative advantage. A further prediction based on the associative deficit hypothesis was that older adults would find it harder than their younger counterparts in recalling the unrelated items because of their difficulty forming new associations. Incorporating a recognition test enabled us to investigate whether older adults would exhibit more FA to consistently re-arranged and consistent new pairs in comparison to the younger adults because of their greater reliance on plausibility.

4.6.1 Recall

As anticipated, the shared relationship manipulation had a significantly greater detrimental effect on recall for integrative pairs relative to the unrelated pairs across both age groups. In particular, it was more pronounced for the older than the younger adults, presumably because of older adults' greater reliance on plausibility and familiarity than on recollection. The shared manipulation had a greater impact on recall of the integrative pairs as performance declined by a greater extent from the unique to the shared condition. As performance declined more so for the integrative than the unrelated pairs in the transition from the unique to the shared relationship, this suggests that specificity and uniqueness are important and necessary components for the integrative advantage to maintain itself. Such uniqueness is clearly not as important for recall of the unrelated pairs as performance decreased by a smaller magnitude in comparison the integrative pairs when the relationship was made less specific.

The shared relationship could have made the role-assignment of the integrative cues less distinct and hence would have made the targets more difficult to retrieve as the cue-target relationship became less specific and unique. Sharing the relationship between the pairs within the list would have increased the number of potential targets shared by the cues, and such an effect was more pronounced among the integrative pairs as the cues within one list could easily have been integrated with any of the other targets due to the shared relationship, resulting in a plausible integrative pair. Recall that a key difference between the unrelated and the integrative pairs is that of role assignment and plausibility: the two words of an integrative pair can be seen to be performing complementary roles, and when put together, the pairs are coherent and they make sense. Moreover, they fit in with our prior knowledge of the world and of concepts around us. This is precisely why having a shared plausible relationship was more damaging to the integrative than the unrelated pairs. Consider some items from the integrative unique list: 'glass jug', 'hospital floor' and 'table map'. All these pairs are unique and involve different relationships – 'glass jug' consists of a made of relation, ‘hospital floor’ consists of a part of relation, and ‘table map’ consists of a location relation. Such differences in relational roles make the integrative pairs specific and narrow down the number of potential targets in memory due to the specificity of the relationship. For example, a participant may remember that glass was paired with a target which was made from glass, not a part of something or located on something, so this specific relationship provides information which limits the amount of viable candidates, and makes accurate recall easier. On the other hand, consider an unrelated unique list with items such as ‘chain wallet’, ‘stable can’ and ‘tooth mail’. Such pairs have no relation to each other and as such do not provide any information which could possibly reduce the number of potential candidates. In the absence of recollection, it is just as likely that chain appeared with mail, that stable appeared with wallet and that tooth appeared with can. Without a plausible relationship to filter out the number of likely targets and without the two words of an unrelated pair performing complementary roles, successful recall becomes much more difficult.

Now consider some items from the integrative shared list with items on the left belonging to the category ‘animal’ and items on the right being in the ‘body part’ category; ‘squirrel nose’, ‘donkey face’ and ‘dog eyes’. As all animals possess body parts, it is entirely plausible that squirrel could have been paired with face, donkey with eyes and dog with nose. Such pairs are just as plausible, and in the absence of using recollection to guide recall, participants are left with a plausibility check; is it likely that squirrel was paired with face? The answer would be ‘yes’ because face is a body part and squirrel was paired with a body part, and squirrel-face makes sense as squirrels have a face. Therefore, all the other plausible candidates serve to make the role of the integrative cue less distinct, and make selecting the correct response all the more difficult. The lack of specificity in the shared integrative condition could have made it difficult to retrieve the correct response as the shared relationship would have resulted in more viable candidates performing plausible complementary roles.

As mentioned previously, the older adults tend to rely more on familiarity and plausibility (Cooper and Odegard, 2012) which is why the effect of the shared relationship on integrative pairs was much more pronounced for them compared to the younger adults. The disproportionate improvement in performance for the older adults relative to the younger adults with the integrative pairs became reduced when the relationship was shared; in other words, the older adults no longer benefitted more than the younger adults from the integratability of the word pairs. This suggests that the specificity and uniqueness of the integrative cue-target relationship is more important to older adults' recall than the younger adults, perhaps because the uniqueness of the relationship filters down the likely response to a smaller number of viable candidates. This could potentially be of a greater benefit to the older adults as research indicates that the elderly have difficulties ignoring irrelevant info (Hasher, Zacks & May, 1999; West & Alain, 2000), so it is possible that when the relationship is made to be shared and the number of potential targets are increased, the older adults have greater difficulty than the younger adults from inhibiting the other competing targets. In addition, in the absence of recollection, the older adults could have struggled more with providing the correct targets to the integrative cues in the shared condition, as they would have placed greater emphasis on what made sense and on what seemed to be an appropriate response.

Although the unrelated shared list would have made recall harder, performance was not expected to have deteriorated that much from the unrelated unique list as both involved absence of plausibility and coherence with long term knowledge. Performance was the lowest in this condition due to the shared relationship and recall would have been particularly difficult due to the absence of a plausible relationship. For example, consider some pairs from the unrelated shared list; 'rose carrot', 'daisy lettuce' and 'lily cucumber'. As there is no obvious relationship between the words of each pair and the pairs do not involve complementary roles, the only information of use to participants would have been the fact that a flower was paired with a vegetable, so rose could have been paired with lettuce, lily with carrot and daisy with cucumber. Participants would have had a greater number of likely candidates in the unrelated shared list as opposed to the unrelated unique one as they would have been aware of the fact that all the items belonged to a certain category. This would have resulted in a bigger selection of appropriate candidates, but would have ultimately resulted in greater difficulty selecting the correct one, due to the absence of a specific and plausible relation.

It could be argued that the significantly lower co-occurrence of the unrelated shared pairs was responsible for the poorest memory performance indexed by the unrelated shared pairs. However, the crucial comparison in this experiment was showing that the integrative pairs would have been more detrimentally affected by the shared relationship (comparison of integrative shared vs integrative unique) than the unrelated pairs (comparison of unrelated shared vs unrelated unique). The fact that the unrelated shared pairs co-occurred together less frequently was likely to have made it more difficult to successfully encode and retrieve the correct response. A future experiment would try to equate co-occurrence as much as possible to reduce the likelihood of it contributing to recall in any way.

In accordance with previous research, there was an overall age effect, with more items being successfully recalled by the younger adults than the older adults. There was no interaction with age between pair type, or between relationship; however the three way interaction between age, pair type and relationship was found to be significant. From looking at the means, it appeared that the older adults were able to benefit more than the younger adults from the specificity and uniqueness of the integrative pairs due to their associative deficit. Older adults demonstrated the typical associative deficit as their mean performance was the lowest with the unrelated unique pairs in comparison to the other conditions. As a result of their initially lower performance with the unrelated unique pairs, their performance increased to a greater extent than the younger adults when integrative unique pairs were introduced.

Due to the older adults' associative deficit which meant performance was initially lower for the unrelated unique pairs, although relationship had a significant effect on recall of the unrelated pairs, the magnitude of this effect was greater for the younger adults - the shared relationship had a much more detrimental effect on younger adults' recall of the unrelated pairs than the older adults. The shared relationship had a greater deterioration in performance for the integrative pairs for the older adults than the unrelated ones. The shared relationship also led to greater declines in memory recall for the younger adults in retrieval of the integrative shared pairs as opposed to the integrative unique ones.

4.6.2 Recognition

Overall, the older adults exhibited a greater proportion of FA to recombined pairs than the younger adults, particularly for the integrative shared pairs when re-combinations would have been consistent with the relations within the list. Even though the relationship manipulation had a greater impact on the proportion of FA to recombined pairs for the integrative relative to the unrelated pairs across both age groups, this impact was significantly greater among older adults in comparison to the younger adults. One explanation for the finding that older adults were inclined to accept recombined pairs as intact relates to recollection and familiarity ('knowing' that something is right). Evidence suggests that whereas familiarity is fairly unaffected in older adults, recollection is largely impaired (Cooper & Odegard, 2012; Light et al., 2000; Prull, Dawes, Martin, Rosenberg & Light, 2006). As the recognition test would have required recollection, older adults' deficiency in recollection coupled with their relatively intact familiarity of the individual items in the recombined pair could have led to the high FA rates of the recombined pairs. Such an increase in FA to recombined pairs by the older adults could be the result of greater reliance on familiarity of the components e.g. animals and body parts, rather than recollection of the association between them. In contrast, the younger adults would have been able to rely on their relatively intact recollection to correctly reject a recombined pair, resulting in fewer FA to recombined pairs than the older adults.

When corrected recognition scores were analysed, the older adults' associative deficit (Naveh-Benjamin, 2000) meant that they benefitted more than younger adults from the integrative pairs when the relationship was unique than when it was shared. The integration between the pairs coupled with their specificity, would have improved recognition considerably more for the older adults due to their difficulties forming new associations between unrelated items. In fact, relationship had no significant effect on recognition for unrelated pairs among the older adults, suggesting that whether the relationship is shared or not does not make a significant difference to the recognition performance of the older adults – their associative deficit means that regardless of the type of relationship, forming associations between unrelated items and correctly recognising them remains difficult.

In accordance with previous results within the thesis, the age difference in recognition was the largest with the unrelated unique pairs. The specificity and integratability of the integrative unique pairs would have benefitted memory performance of the elderly more so than the younger adults, which is why higher recognition scores were demonstrated with these pairs. Recombined integrative unique pairs would have been inconsistent with the overall list characteristics (because each pair had a unique and specific relationship), so it would have been more evident that a re-arranged pair was inconsistent with the rule, and therefore must not have been presented at study, resulting in higher recognition scores (as well as a smaller number of FAs to recombined pairs). With regards to the unrelated unique pairs, as older adults' memory for such pairs would have been limited in the first place because of their associative deficit, it is thought that the older adults would have had no strategy to make a decision as to whether a re-arranged unrelated unique pair was present or not during study. Due to the older adults' difficulty recollecting past details, they would have been more likely than the younger adults to falsely recognise a re-arranged unrelated unique pair, resulting in a greater proportion of false alarms, and consequently a lower recognition score. In the absence of recollection, the older adults would have assumed that a re-arranged unrelated pair was present as it fit the rule of being 'unrelated' and familiar (as both words had been encountered before).

The lower recognition scores for the integrative shared pairs across older and younger adults indicated that the ability to discriminate an old response from a new response became harder when the integrative pairs were no longer specific. The shared relationship would have made it increasingly difficult to differentiate between an old pair and a new pair as both recombined and new pairs would have been consistent and plausible with the concept of integratability, and the two words within the recombined and new pairs would have performed complementary roles, therefore according with the role assignment model. For example, consider that the pairs 'dog nose' and 'cat head' were present during study. At recognition, it is just as plausible that 'cat' was paired with 'nose' and that 'dog' appeared with 'head' as they are both body parts belonging to animals, and the either of the targets could plausibly perform the role brought on by any of the cues. The shared relationship presumably did not have as much of an impact on the unrelated pairs as they were initially unrelated in the first place, so whilst a shared relationship would have made it hard to discriminate an old response from a new one, it would not have much of an effect as it did on the integrative pairs because unrelated pairs lack the characteristics of plausibility, role-assignment and specificity.

As with recall, the disproportionate advantage in recognition exhibited by the older adults compared to the younger adults with the integrative unique pairs became reduced with the addition of a shared relationship, implying that the uniqueness of the integrative pairs was more integral to older adults' performance than the younger adults, and that the older adults were able to benefit more than the younger adults from the specificity and uniqueness of the integrative pairs. It could be argued that the older adults' difficulties with inhibitory control (Hasher et al., 1999; VanWormer, Bireta, Surprenant & Neath, 2012) together with greater reliance on familiarity and plausibility could offer an explanation for the reduction in the integrative advantage when the relationship was shared due to their reduced ability relative to the younger adult to ignore competing targets and their increased likelihood of accepting a consistently re-arranged/new pair because of familiarity and plausibility.

In summary, whilst the shared manipulation clearly had an impact on recall and recognition of the integrative pairs, the integrative advantage was still apparent, with performance of the integrative shared pairs being significantly greater than that of the unrelated unique pairs across both age groups. It seems that the facilitated performance of the integrative pairs relative to the unrelated pairs is a robust finding which extends beyond that of uniqueness and plausibility.

Chapter Five: General discussion

5.1 Thesis rationale and goals

The overall goal of this thesis was to investigate the mechanisms through which pairs with an integrative quality could reduce the associative deficit typically portrayed by the elderly. Four key areas were examined: 1) whether associative strength was responsible for the advantage of integrative over unrelated pairs; 2) whether relational processing was crucial; 3) whether imagery through relational processing played a role and 4) whether uniqueness, specificity and plausibility were necessary characteristics which needed to be possessed for a pair to be considered integrative.

Research indicates that older adults portray an associative deficit, where they have difficulty forming new associations between single units of information (Chalfonte & Johnson, 1996; Naveh-Benjamin, 2000). Findings demonstrate that this associative deficit can be reduced in tasks which place less emphasis on the creation on new associations. In particular, when older adults are able to rely on pre-existing knowledge (such as through the use of semantically related word pairs) age differences are minimized, and the associative deficit is attenuated. Therefore, it is reasonable to assume that pairs lacking these pre-established associations would result in deficits in associative memory performance. However, Badham et al. (2012) demonstrated that pairs which were integrative and which lacked pre-existing associations, reduced the age-related difference in comparison to unrelated pairs, and consequently older adults' associative deficit. This implies that older adults are in fact capable of forming new associations in the absence of pre-existing associations. However, in the Badham et al. (2012) study, some of the pairs did have pre-established associations, suggesting that associative strength was a possible reason for the reduced age difference. The first experiment attempted to find out whether pre-existing associations were responsible for the integrative advantage reported by Badham et al. (2012) by separating the integrative word pairs into two types of lists – one which had pre-existing associations and one which lacked these associations. These lists were compared to an unrelated list across both older and younger adults. It was predicted that recall would be greater in the list with pre-existing associations and consequently would produce a smaller age difference. In addition, it was predicted that performance for the integrative non associative pairs would resemble that of the unrelated pairs due to both being devoid of any pre-existing associations.

Experiments 2, 3a and 3b attempted to ascertain whether relational processing was responsible for the integrative advantage. This was achieved by directing participants to engage in item-specific processing and verifying if this would align performance with the integrative pairs to performance with unrelated pairs.

Experiment 4 investigated whether relational processing induced through the use of interactive imagery could abolish the advantage of the integrative pairs.

The final experiment sought to investigate the impact of shared relational roles on the integrative pairs, and whether uniqueness played a role in the integrative advantage. This involved having a condition where the integrative pairs within a list shared the same relationship e.g. 'made of'; memory for the latter was compared to a condition where each integrative pair had its own unique relationship within the list e.g. 'part of', 'located on', 'made of' etc. Memory performance was assesses through cued recall as well as recognition. It was anticipated that recall of the integrative pairs with a shared role would be more detrimentally affected due to difficulties selecting the correct target from a number of viable possibilities. For the recognition task, it was believed that the older adults would produce more false alarms (FA) to plausible recombined pairs (shared context) than the younger adults, due to their greater reliance on plausibility and familiarity than on recollection. In addition, it was anticipated that the shared relationship manipulation would be more detrimental to the integrative pairs than the unrelated ones, because the advantage of integrative pairs was thought to involve specific relational roles, as well as plausibility; characteristics which are not present in the unrelated pairs.

5.2 Review of empirical work and theoretical implications

The goal of the first experiment was to see whether the superiority of the integrative over unrelated words could possibly be explained via pre-existing associations. Naveh-Benjamin (2000) demonstrated that older adults have difficulty forming novel associations between items; they portray an associative deficit whereby they have difficulty encoding and retrieving new associations. Based on the ADH, we would have expected performance of the integrative non-associative pairs to resemble that of the unrelated pairs for the older adults, due to the lack of prior associations. In addition, recall was anticipated to be the highest with the integrative associative pairs due to the prior associations facilitating recall – participants could rely on long term knowledge of associations to help in the retrieval process. Consequently, the age-related difference was predicted to be the smallest in this condition, and larger in the other two. In accordance with the view that pre-existing associations are beneficial to memory performance, especially for the older adults, the smallest age difference was obtained where integrative pairs had associations existing between them. However, inconsistent with the ADH view that older adults have difficulties forming new associations was the finding that the integrative non associative pairs were recalled significantly better by the elderly than the unrelated pairs. As level of association was equated between the integrative non associative and the unrelated pairs (both had no association to each other), the only difference between them was that of integratability. Integration allowed the two words to be encoded more easily than words which were unrelated, as it involved sub-classification i.e. the first word (modifier) specified a subclass of the second word (head noun) so that they jointly referred to a single concept. For example, lemon cake is a specific type of cake, and monkey foot is a specific type of foot (Estes & Jones 2009). Research has shown that such integrative relations facilitate memory performance (Badham et al., 2012; Estes & Jones, 2009; Jones, Estes & Marsh, 2008). As the words in the integrative pairs were unassociated and semantically dissimilar, their reduction of the age difference cannot be completely ascribed to pre-existing relations. The older adults constructed concepts which fitted in with their knowledge of the world, which is possibly why such pairs were less difficult to encode and/or retrieve than the unrelated pairs. Integrative pairs were perhaps easier to meaningfully encode as they related to worldwide concepts and long term knowledge. This is consistent with the view that the less effort that is involved in processing items, the smaller the age difference will be (Fastenau, Denburg & Abeles, 1996). It is also likely that the integrative pairs were easier to retrieve than the unrelated ones as long term knowledge of integrative relations during recall could have aided in narrowing the memory search for the matching target. Such knowledge may have provided greater environmental support (Craik, 1986) which has been found to benefit the elderly more so than the younger adults. In effect, the integrative pairs are an example of how prior knowledge and semantic memory can benefit the episodic memory performance of the elderly (Badham & Maylor, 2015; Castel, 2005; Castel, McGillivray & Worden, 2013; Umanath & Marsh, 2014).

As mentioned previously, relational processing could have provided a means by which integrative pairs facilitated performance; knowing that a word pair is integratable requires knowledge of the fact that the words *can* be integrated together, which then leads to relational processing as the two words have to be related with each other in some way. In order for a pair to be considered integrative, it has to make coherent sense, and must involve sub-classification, and deciding whether a word pair meets these criteria must involve some form of previous/long term knowledge, as well as the capacity to *relate* the concepts successfully together. From this viewpoint, it could be argued that relational processing could explain the integrative advantage and was important for the integrative advantage to manifest itself. Experiment 2 attempted to discover what would happen to the integrative advantage if relational processing was prevented in some way.

The second experiment compared the effects of item-specific and relational processing on older and younger adults' recall of the integrative and the unrelated pairs. It was anticipated that directing participants to focus on item-specific properties of the integrative pairs would reduce or even remove the advantage, thereby equating performance with the unrelated pairs (because of the lack of relational processing deemed to be necessary for the manifestation of the integrative advantage). An overview of the literature suggested that older adults were just as capable as younger adults from benefitting from both forms of processing, but that they showed a bias to item-specific over relational processing, presumably because of their associative deficit (Hultsch, 1969; Luszcz et al., 1990; Naveh-Benjamin, 2000; Rankin & Firnhaber, 1986). Findings from the second experiment indicated that explicitly directing both older and younger adults' attention to item-specific properties of the integrative pairs did not remove the integrative advantage; integrative pairs were still correctly recalled at a significantly higher rate than the unrelated pairs in the item-specific task. One interpretation was that the integrative pairs uncontrollably encouraged relational processing, so that even when participants were explicitly instructed to focus on item-specific properties, they could not help but make relational links between the integrative pairs and hence process relational information. The role assignment model of relational concepts (Estes & Jones, 2009) holds promise as a likely and appropriate model for explaining the facilitated memory performance of the integrative pairs. In integrative pairs, the cue (first word) can easily be integrated with the target (second word) thereby creating a unitary representation. According to the role assignment model, the words within each pair must be seen to perform complementary roles i.e. the containment relation (shoe box) involves complementary roles of contained and container. Establishing a likely relation between two concepts isn't enough for relational integration; engaging in a role assignment process and allocating those concepts to complementary roles is deemed crucial (Estes, 2003; Jones & Love, 2007). For example, the compounds 'factory smoke' and 'fruit tree' both entail a production relation, however, the producer role occurs as a modifier in the first instance and as a head in the second one. Therefore, deducing a relation that is appropriate is inadequate for complete comprehension; engaging in a process where decisions can be made concerning which roles are performed by which concepts is necessary and crucial. As mentioned previously, it was believed that the relational processing brought on by the integrative pairs was uncontrollable, which is presumably why the integrative advantage was still apparent when participants were instructed to focus on item-specific properties of the integrative pairs. Mather, Jones & Estes (2014) proposed that the activation of complementary roles was an uncontrollable process as they conducted two experiments which suggested that integration between cue and target was out of participants' strategic control. According to Mather et al. (2014), when the two words of an integrative pair can be seen to be performing complementary roles, the 'search for a plausible relation between the [cue] and target is terminated quickly and [recall] is facilitated' (p.66). However, if a plausible relation which integrates the cue and target is difficult, as in an unrelated pair, then recall is likely to be detrimentally affected. The uncontrollable aspect of the integrative advantage accords with previous research (Jones, 2013; Lerner et al., 2012; Masson, 1995) which showed that semantic features and associated concepts are activated automatically following word presentation. So 'to the extent that those semantic features and associated concepts are sufficient to identify a word's relational role(s), role activation would also occur automatically' (Mather et al., 2014, p. 67).

Such relational processes can either occur prospectively or retrospectively; in the prospective case, when presented with an integrative cue such as cotton, it is possible that this cue pre-activates the target before it is actually presented. This is because the cue (cotton) activates its most typical role (material) which then activates its complementary role (clothing) which in turn activates a selection of components which are typical of that role (e.g. shirt, blouse, scarf). Thus initial presentation of the cue could result in participants making judgements as to what the other target word could potentially be, and if they notice that the second word does in fact relate to the first word and can be integrated together coherently, then focusing on item-specific properties will have little or no effect – integration and hence relational processing would have already occurred. Regarding retrospective evaluation, both the typical and complementary role of the cue are activated, followed by a retrospective check of whether the presented target could realistically perform that complementary role (e.g. whether a shirt can be made of a material). Both views argue that initial presentation of the cue leads to complementary role activation so asking participants to solely direct their attention to item-specific properties of each word could be argued to be redundant. However, from looking at the results, we can see that getting participants to engage in item-specific processing of the integrative pairs was not entirely redundant as type of processing did have a significant impact on recall of the integrative pairs, particularly among the elderly. One possible explanation for the older adults' lower recall than the younger adults on the item-specific task with the integrative pairs could be the limited resources view (Craik, 1986). It could be the case that younger adults were more able to spontaneously engage in relational processing even in the item-specific task due to the greater attentional resources they possess in comparison to the elderly. Such an explanation could account for the younger adults' better performance than the older adults in recall of the integrative pairs in the item-specific task. The older adults were unable to effectively employ spontaneous processing and so their performance suffered as a result. In addition, the fact that the elderly benefit from directed processing instructions could mean that when they were asked to process the word pairs in an item-specific way, they focused all of their attention and resources into processing them in a way which was required by the experimenter. Therefore, they were less likely to be contaminated by the effects of spontaneous relational processing. This could be a possible explanation for the greater sensitivity among the elderly in the item-specific task for the integrative pairs.

The relational task led to similar levels of improvement in performance for both the young and older adults, so although the elderly benefitted slightly more, this difference was not significant and accords with previous research stating that older adults benefit as well as the younger ones when relational tasks are used (Fisher & McDowd, 1993; Luszsc et al., 1990).

Among older and younger adults, the relational task overall resulted in better memory performance than the item-specific task. This is because the memory task was a cued recall one and so made use of the relational links participants formed during the relational task. The sentence construction task enabled pairs to be related together in a coherent and plausible way, and it could be argued that as the memory task was a cued recall one, it increased the encoding-retrieval match which is believed to be beneficial to memory performance (Tulving, 1983). Conditions at retrieval matched those at encoding which is why performance benefitted from the relational task more so than from the item-specific task. In terms of the present experiment, the relational task provided a greater match to the cued recall test as the task required them to use an associative technique to relate the words together. In order to perform well on a cued recall test one must have created and encoded an associative link between the cue and target, which the relational task would have provided. On the other hand, although there is still a match in the item-specific task as the same cues are presented in the cued recall test, the degree of overlap is not as high as it is with the relational task, which more closely resembles the cued recall test. The pleasantness task does not induce associative processing and as such does not provide as close a fit to the cued recall procedure as the relational task.

Results from the second experiment were on the whole consistent with previous literature with regards to aging; the older adults: 1) showed evidence of the ADH depicted by their poor performance with the unrelated pairs in the item-specific task 2) were just as able to benefit from the relational task as younger adults 3) showed evidence of possessing limited resources for spontaneous effortful retrieval and 4) demonstrated the largest age difference in recall of the unrelated pairs. In addition, the older adults benefitted more from relational processing of the unrelated pairs than the younger adults (due to their ADH). Thus the current results were in line with the predictions and previous findings. However, an unexpected finding was the presence of the integrative advantage in the item-specific task. As mentioned previously, it was possible that the presentation format of the integrative pairs, which could have instigated uncontrollable relational processing, along with a less elaborative item-specific task, may have contributed to the prevalent superiority of the integrative over the unrelated pairs in the item-specific task. Experiments 3a and 3b were conducted to see whether these improvements would lead to the removal of the advantage.

The third experiment(s) were successful in removing the integrative advantage for both older and younger adults by using a more elaborative item-specific task and by varying the presentation mode so that the words of each pair were presented one at a time. It appeared that focusing on item-specific properties of the integrative pairs, particularly when the words within each pair were presented one at a time, prevented participants from successfully integrating the pairs together and from benefitting from their advantageous property. This implies that the mechanisms responsible for the advantage could possibly be explained through the use of priming and long term knowledge; presenting the cue word of an integrative pair could pre-activate the target before the targets actual presentation through the concept of role typicality (Estes & Jones 2009). According to Estes, 'integrative priming occurs because the prime word (*forest*) activates its typical role (*locale*), which in turn activates its complementary role (*object*), which then activates a set of typical fillers of that role (e.g., *bird*, *stream*, and the like). Lexical decisions are facilitated for target words that are typical of the complementary role' (Estes & Jones, 2009, p. 125). By this notion, it could be argued that focusing on the cue word of an integrative pair activated a set of likely candidates; all of which could have successfully performed a given role and may have therefore acted as a suitable target. In the present experiment, directing participants' attention to each word of the integrative pair by focusing on item-specific properties (when the words of each pair were presented one at a time) could have prevented this activation from taking place, making the beneficial effects of the integrative relationship redundant, even when the corresponding integrative target was presented. As participants' attention was focused on constructing a sentence for each word of an integrative pair; limited cognitive resources would have been available for searching for a likely integrative target, therefore making the presentation of the corresponding integrative target of little use (because the connection wouldn't have been established due to concentration on the item-specific task).

Difference in recall between the integrative and unrelated pairs was significant in the item-specific task when items were presented simultaneously, indicating that the integrative advantage may have been partly due to fact that the integrative words appeared together; seeing the integrative words side by side most likely uncontrollably activated stored representations/long term knowledge of relational concepts, which in turn led to relational processing of the integrative words in the item-specific task.

Presentation did not have an impact on recall of the unrelated words, perhaps because seeing unrelated words appear together is unlikely to uncontrollably promote relational processing; without a link to bind or relate the words together, the chances of engaging in relational processing without instruction are remote. This was demonstrated by the results, as recall for the unrelated pairs in the item-specific task with one by one presentation for the younger adults was the same with simultaneous presentation in the same condition. For older adults recall for unrelated pairs in the item-specific task with one by one presentation was not significantly different to recall with simultaneous presentation.

Smaller age differences were obtained in recall of the integrative pairs than the unrelated ones due to the lack of pre-existing associations embodied by the unrelated pairs. Age differences were minimized as the integrative stimuli enabled participants to rely on long term previous knowledge to establish relational links between the items. The smallest age difference was demonstrated in recall of pairs in the relational task as explicit instructions to encode the words in a relational way would have substantially increased performance and would have enabled participants to make connections between the words, thereby using a form of long term knowledge. Due to the older adults' significantly poor performance of the unrelated pairs in the item-specific task, they benefitted more from the relational processing of the unrelated items than the younger adults. This coincides with the results from Experiment 2 which found the relational task had a greater impact on recall of the unrelated items for the elderly than it did for the young. The older adults tended to benefit more from relational information and integration with regards to item-specific information as compared to younger adults. This was based on the observation that the difference in performance between unrelated and integrative items tended to be greater in the older adults than in the younger ones, with age differences being generally bigger for unrelated items. Such a finding was in line with the ADH as it was assumed that the younger adults spontaneously engaged in relational processing even for unrelated material, which older adults could not do because of their associative difficulties. However, it could well be the case that older adults were simply worse at item memory, which is why they were able to benefit more than their younger counterparts from relational processing. The findings from Experiments 3a and 3b appear to support this viewpoint, as one at a time presentation seemed to prohibit relational processing by the younger adults, and showed that the older adults were not really worse than the younger ones.

Again, in line with findings from Experiment 2, the relational task overall resulted in better memory performance than the item-specific task across both age groups, thereby supporting the notion of the encoding-retrieval match (Tulving, 1983). The relational sentence construction task enabled pairs to be related together in a coherent and plausible way, and as the memory task was a cued recall one, it increased the encoding-retrieval match which is thought to be beneficial to memory performance (Tulving, 1983).

In summary, Experiments 3a and 3b were both successful in removing the integrative advantage in the item-specific task when a more elaborative task as well as one by one presentation of each word in the pair was adopted. Findings indicate that we uncontrollably process integrative words in accordance with previous knowledge when they are encountered at the same time, and try to make sense of them the best we can. This was demonstrated by the failure to remove the advantage in the item-specific task in Experiment 2 when the words of each pair were presented simultaneously. However, when a cognitively demanding task was performed on the integrative pairs which prevented participants from successfully relating them together, in addition to seeing each word of the pair separately (thereby removing the visual memory), the advantage disappeared.

Therefore, the ability to engage in successful and undisturbed relational processing is crucial for the integrative words to be of benefit to recall.

Interestingly, the integrative advantage was still apparent in the relational task; integrative pairs were recalled significantly better than the unrelated pairs. Based on the belief that the integrative advantage is maintained and explained by relational processing, we would expect that the relational processing of the unrelated pairs would have led to a similar level of performance to the integrative pairs. Yet the integrative advantage still present, suggesting that these pairs possess some other component, other than relational processing, which could explain their advantage. If the integrative advantage were largely due to relational processing, than one might expect both integrative and unrelated pairs to be recalled equally well when relational processing was introduced; however this was not the case with the advantage still being present in the relational task.

Experiment 4 investigated the relational component in more detail by instructing participants to utilise an interactive imagery encoding strategy as well as a learn strategy. Experiments 2, 3a and 3b indicated that the integrative advantage persisted when relational processing was encouraged through the use of sentences, so what if relational processing were to be encouraged through some other medium, such as interactive imagery? As relational processing was thought to be pivotal to the facilitated performance of the integrative pairs, the rationale was that explicitly asking participants to use interactive imagery (which is essentially a form of relational processing) would boost performance of the unrelated pairs relative to the learn condition, and perhaps result in the unrelated pairs behaving like the integrative ones in the imagery condition, leading to the removal of the integrative advantage.

The older adults benefitted more from the use of imagery than the younger adults for the unrelated pairs, suggesting that they were able to effectively engage in and employ useful processing strategies. Therefore, interactive imagery was successful in reducing the associative deficit older adults typically show with the unrelated pairs. It seems that engaging in processes which integrate pairs together, as well as imagining the words visually interacting in some way, can have a positive impact on recall for pairs which previously had no semantic connection or association to each other. Thus results do not appear to support Craik's (1979) limited resources view as this would have predicted little improvement in older adults' memory performance from using the rehearsal to the imagery strategy on the unrelated pairs due to the fewer processing resources they had available to them; such limited resources would have made the ability to engage in self-initiated processing difficult. Therefore, older adults are capable of engaging in effective processing strategies when they are instructed to do so.

As anticipated, the biggest age difference was observed in recall of the unrelated pairs in the rehearsal condition, thus demonstrating the associative deficit of older adults, and their difficulty forming new associations (Naveh-Benjamin, 2000). The fact that the older adults benefitted more from the imagery strategy in recall of the unrelated pairs suggests that their performance was initially lower with these pairs under rehearsal strategies. Research indicates that the elderly are less likely to spontaneously use appropriate processing strategies in comparison to their younger counterparts (Naveh-Benjamin 2000, Naveh-Benjamin et al., 2007; Rogers et al., 2000). The general consensus is that older adults engage in less spontaneous use of associative strategies, and as a consequence their performance deteriorates when asked to recall associative information, thus demonstrating the typical associative deficit. However, when older adults are explicitly directed to employ appropriate learning strategies, they show improvements in performance and are able to benefit from strategy use.

Overall, the results suggest that the elderly can use imagery as an effective learning strategy to facilitate associative recall and supports previous findings (Cohn, Emrich &Moscovitch, 2008; Dunlosky, Hertzog &Powell-Moman, 2005; Kuhlmann & Touron, 2012; Patterson & Hertzog, 2010). Taken together, they indicate that using interactive imagery as a means of encoding word pairs in paired associate learning paradigms is a successful strategy which can facilitate recall for both older and younger adults. Images aroused by stimuli can be combined into complex images which are 'functionally unitary, integrated memory structures' (Begg, 1972, p.431). Within this integrated memory structure the elements interact with each other to form a meaningful figure/conceptual unit, and the integrated memory representation leads to enhancement of recall.

Interestingly, the integrative advantage was still present in the imagery task for both older and younger adults. This implies that apart from encouraging relational processing, the integrative pairs possess some other quality which could explain their advantage. Perhaps integrative pairs differ from the unrelated ones in terms of their specificity and plausibility? Experiment 5 investigated whether uniqueness and plausibility were necessary components in the integrative advantage.

In the final experiment, the relationships of the pairs were manipulated in addition to presenting participants with a recognition test. Integrative and unrelated pairs were encountered by both older and younger adults, with half consisting of a shared relationship within each list and half consisting of a unique relationship. It was predicted that items belonging in the shared conditions would be more difficult to recall than those in the unique conditions as a result of the shared targets being highly overloaded and more difficult to retrieve. Such a difference was expected to be more pronounced with the integrative pairs than with the unrelated ones, on account of the integrative pairs promoting specificity and uniqueness, making them highly sensitive to the shared manipulation. In terms of aging, the greatest age differences were expected among the unrelated as opposed to the integrative pairs due to older adults' associative deficit. Moreover, it was anticipated that the older adults would exhibit a greater proportion of false alarms to consistently re-arranged items than the younger adults due to their difficulties recollecting past details and their reliance upon plausibility and familiarity.

As predicted, memory recall for both integrative and unrelated pairs suffered from the shared relationship manipulation, and the shared relationship had a much more detrimental effect on recall of the integrative pairs than the unrelated ones, suggesting that specificity and uniqueness of relational roles are important and necessary components for the integrative advantage to manifest itself. Such uniqueness appears not to be as important to recall of the unrelated pairs as it is to the integrative pairs as performance decreased by a smaller magnitude compared to the integrative pairs when the relationship was made less specific. The shared relationship could have made the role-assignment of the integrative cues less distinct and therefore would have made the targets more difficult to retrieve as the cue-target relationship became less specific and unique. Sharing the relationship between the pairs within the list would have increased the number of potential targets shared by the cues, and such an effect was more pronounced among the integrative pairs as the cues within one list could easily have been integrated with any of the other targets due to the shared relationship, resulting in a plausible integrative pair. A key difference between the unrelated and the integrative pairs is that of role assignment and plausibility: the two words of an integrative pair perform complementary roles, and when put together, the pairs are coherent and they make sense. Moreover, they fit in with our prior knowledge of the world and of concepts around us. This is exactly why having a shared plausible relationship was more damaging to the integrative than the unrelated pairs. Consider some items from the integrative unique list: 'glass jug', 'hospital floor' and 'table map'. All these pairs are unique and involve different relationships – 'glass jug' consists of a 'made of' relation, 'hospital floor' consists of a 'part of' relation, and 'table map' consists of a 'location' relation. Such differences in relational roles make the integrative pairs specific and narrow down the number of potential targets in memory due to the specificity of the relationship. For example, a participant may remember that glass was paired with a target which was made from glass, not a part of something or located on something, so this specific relationship provides information which limits the amount of viable candidates, and makes accurate recall easier. On the other hand, consider an unrelated unique list with items such as 'chain wallet', 'stable can' and ‘tooth mail’. Such pairs have no relation to each other and as such do not provide any information which could possibly reduce the number of potential candidates. In the absence of recollection, it is just as likely that ‘chain’ appeared with ‘mail’, that ‘stable’ appeared with ‘wallet’ and that ‘tooth’ appeared with ‘can’. Without a plausible relationship to filter out the number of likely targets and without the two words of an unrelated pair performing complementary roles, successful recall becomes much more difficult.

In terms of the integrative shared pairs, the other plausible targets (candidates) serve to make the role of the integrative cue less distinct, and make selecting the correct response all the more difficult. The lack of specificity in the shared integrative condition could have made it harder to retrieve the correct response as the shared relationship would have resulted in more viable candidates performing plausible complementary roles.

In accordance with previous research, the older adults demonstrated the typical associative deficit as for the unrelated unique pairs. Consequently, the older adults were able to benefit more from the integrative pairs than the younger ones. Moreover, it seemed that the effect of the shared relationship manipulation on the integrative pairs was much more pronounced for the older adults relative to the younger adults. This could be due to their increased reliance on familiarity and plausibility (Ahmad, Fernandes & Hockley, 2015; Cooper & Odegard, 2012). In the absence of recollection, the older adults could have struggled more with providing the correct targets to the integrative cues in the shared condition, as they would have placed greater emphasis on what made sense and on what seemed to be an appropriate response.

Regarding the recognition data, a greater proportion of FA was demonstrated by the older adults than the younger ones, presumably because of their increased reliance on familiarity and plausibility rather than on recollection. More specifically, the older adults exhibited a greater proportion of FA to recombined pairs than the younger adults, particularly for the integrative shared pairs when re-combinations would have been consistent with the relations within the list. One explanation for the finding that older adults were inclined to accept recombined pairs as intact relates to recollection and familiarity ('knowing' that something is right). Evidence suggests that whereas familiarity is fairly unaffected in older adults, recollection is largely impaired (Cooper & Odegard, 2012; Light et al., 2000; Prull, Dawes, Martin, Rosenberg & Light, 2006). As the recognition test would have required recollection, older adults' deficiency in recollection coupled with their relatively intact familiarity of the individual items in the recombined pair could have led to the high FA rates of the recombined pairs. Such an increase in FA to recombined pairs by the older adults could be the result of greater reliance on familiarity of the components e.g. animals and body parts, rather than recollection of the association between them. In contrast, the younger adults would have been able to rely on their relatively intact recollection to correctly reject a recombined pair, resulting in fewer FA to recombined pairs than the older adults.

One interesting finding was the fact that corrected recognition did not differ significantly between the unrelated shared and the unrelated unique conditions for the older adults, whereas it did among the younger ones. This suggests that the type of relationship was not as pivotal to the older adults' ability to differentiate an old response from a new one for the unrelated pairs as it was for the younger adults. It seems that the younger adults were able to benefit more from the unique relationship of the unrelated pairs as their corrected recognition score, and hence ability to differentiate an old from a recombined/new response, was significantly higher for these pairs than it was for the unrelated shared ones. On the other hand, older adults' associative deficit would have made it difficult for the elderly to form new associations, and as a consequence would have resulted in greater difficulties discriminating an old unrelated pair from a new unrelated pair, regardless of whether the relationship was shared or not, producing similar recognition rates across both unrelated shared and unrelated unique conditions.

Across all experiments, except for 3a and 3b, using different materials and stimuli, employing various ways of assessing memory performance and with different sets of participants, the finding that the older adults benefitted more than the younger adults from the integrative pairs was replicated. The first experiment showed a disproportionate advantage for the older adults relative to the younger adults with the integrative pairs compared with the unrelated ones; the second indicated a similar benefit with the item-specific task, the fourth demonstrated the same disproportionate advantage in the rehearsal task, and the final experiment showed similar findings with unique relationships. This disproportionate advantage is thought to reflect the older adults' considerably poor performance with the unrelated pairs in the item-specific and rehearsal tasks, as these conditions do not enable necessary and crucial relational processing techniques to take place, therefore increasing the magnitude of the associative deficit. However, when conditions enable older adults to increase relational processing of the unrelated pairs, either through a relational or imagery task, and through shared relationships, performance for unrelated pairs increases substantially, thereby reducing the associative deficit as well as the magnitude of improvement brought on by the integrative pairs, resulting in a similar gains in performance as the younger adults from the integrative pairs.

In summary, findings across all the experiments conducted within the thesis were able to replicate the typical associative deficit of the elderly, thus supporting the ADH; however, it could well be the case that older adults' memory is simply worse overall, and that they are guessing when it comes to associative recall/recognition. An alternative hypothesis to the ADH and which could potentially offer a plausible explanation for the overall deficit in older adults' memory is the density of representations yields age-related deficits (DRYAD) model (Benjamin, 2010). The ADH is specific in that it only focuses on associative memory, whereas DRYAD is a much more general model which looks at overall memory. According to DRYAD, disproportionate deficits in memory can be attributed to a global deficit of memory, as opposed to a selective one. The theory proposes that global differences in memory fidelity between older and younger adults accounts for the deficits in memory exhibited by the elderly. In other words, older adults' representations of objects and events are less valid than that of their younger counterparts. DRYAD can explain associative recognition in the following way: The presentation of a word-word pair is encoded into a single memory representation, and then evaluated during the memory test using the familiarity mechanism to assess recognition of intact (compared to recombined and new) word-word pairings. For each trial, the word-word paring is 'encoded into the DRYAD's memory with a degree of fidelity governed by the learning parameter…the noise generated by that process applies to the entire memory trace, regardless of whether a particular dimension represents information about the [first word or the second word] (Benjamin, 2016, p.16). The global matching mechanism underlies DRYAD and enables the model to differentiate intact from re-arranged word-word pairings. If the first and the second words are stored in memory, there will be a greater match if these two items are kept in the same memory trace. As overall learning increases, there is also an increase in the rate at which associative recognition increases with each unit of learning, therefore predicting a disproportionate decrease in associative recognition (or not) dependent upon the overall degree of learning. The critical difference between DRYAD and the ADH concerns how memory is viewed; ADH breaks down memory selectively in terms of associations, whether it is item-item or item-context associations, whereas DRYAD views memory as an overall global system, which is not selectively limited, but generally limited (see Benjamin, 2010, 2016 for a more extensive description of the DRYAD model).

In sum, the integrative advantage was maintained in all experiments, except for 3a and 3b, where complete separation of the integrative pair along with an elaborately demanding item-specific task was successful in removing it across both age groups. This highlights the robustness of the advantage, and how it can still persist despite substantially improving the performance of the unrelated pairs through relational processing and imagery. It also suggests some other component, apart from specificity, imagery and relational processing may be responsible, and such a component (or indeed components) is likely to be understood through further research and experimentation. Overall though, it seems that the integrative advantage is likely to be explained by the role assignment model of relational integration.

5.3 Limitations and future directions

One of the limitations of the thesis concerns the stimuli used to assess memory performance. The use of integrative and unrelated word pairs could be argued to be artificial as they have no particular relation to everyday life and as such do not provide an appropriate way of investigating memory in everyday situations. On the other hand, throughout the experiments conducted within the thesis, it is clear that the integrative pairs do rely on some form of prior knowledge, which necessitates their use as it provides an example of how knowledge built up from real life experiences can aid with the processing and retrieval of information. Future studies may wish to address this issue by perhaps using stimuli which relates more specifically to people's everyday experiences. For example, applying integrative word pairs to normal scenarios such as going to do the weekly shop or meeting new people. Such explorations would increase the validity of the integrative pairs and would possibly provide further evidence of how prior semantic knowledge can benefit episodic memory performance of the elderly.

Another limitation concerns the co-occurrence of the word pairs. Efforts were made to equate the integrative and unrelated pairs on local co-occurrence assessed via Google hits, to prevent prior word-word familiarity being a possible factor in the enhanced memory performance of the integrative pairs. As Google hits is based on current trends, the co-occurrence values can change from day to day. Therefore, although Google hits were obtained for all stimuli for a particular experiment on the same day, it is probable that the values would have changed from construction of the stimuli to the actual running of the experiment and gathering of the data. This means that the integrative and unrelated pairs might not have been equated on co-occurrence as previously thought, suggesting that and differences in performance obtained between the two pair types could have been the result of differences in familiarity. Future research could acquire co-occurrence values prior to testing on each day to ensure that the Google trends are fairly stable.

A further issue with co-occurrence was the fact that attempting to equate integrative and unrelated pairs on co-occurrence resulted in the construction of a limited number of unrelated pairs, which were perhaps not fairly typical. Rather than trying to match local co-occurrence, future studies could simply construct stimuli which meet the necessary parameters of being integrative and unrelated, and then use the co-occurrence values as covariates when analysing the data. This would demonstrate that the integrative advantage could also be achieved with a bigger selection of more typical unrelated pairs.

The final experiment indicated the harmful effects of incorporating a shared relationship with the integrative pairs. The shared relationship was operationalised in a way in which semantic categories were used to instigate shared relations; the items on the left belonged to one category and the items on the right belonged to another, with the constraint that the two categories could be integrated plausibly together by one shared relationship e.g. the relationship 'made of' achieved by having 'type of material' on the left and 'type of clothing' on the right. Experiment 5 indicated that benefits on recall of having unique relationships in comparison to shared relationships, and closely related to the idea of uniqueness is that of distinctiveness. The concept of distinctiveness has been defined in many ways, however, in this instance we are concerned with the definition of distinctiveness as the processing of a difference in the context of similarity (Hunt, 2006). Research has shown that the more distinctive an item is relative to other items, the better the memory for that particular item (Bireta et al., 2008; Brown & Lloyd-Jones, 2006; Einstein, 1987; Hunt, 2006; Hunt & McDaniel, 1993). Distinctiveness within the integrative pairs could be manipulated by having a list where all the integrative pairs consist of the same relationship i.e. 'made of'; with the exception that one pair consists of a different relationship i.e. 'located on'. Memory for the critical distinctive pair could be compared to a list where all the items have the same relationship to the critical pair ('located on') to see whether memory is facilitated for the critical pair when it is distinctive. This would contribute to distinctiveness research showing the beneficial effects of distinctiveness and uniqueness.

5.4 Summary

In conclusion, the role assignment model of relational concepts appears to offer a plausible and viable explanation of the superiority of integrative over unrelated pairs, and their ability to reduce the associative deficit typically portrayed by the elderly. The series of experiments conducted within the thesis demonstrate that the facilitated memory performance of older and younger adults instigated by integrative pairs is separate from associative strength, as well as co-occurrence, and that such pairs appear to rely on prior semantic knowledge , which aids with the relational processing of relevant roles. When an integrative cue is presented, the activation of complementary role candidates occurs uncontrollably (Estes & Jones, 2011; Mather et al., 2014) and integrative facilitation presents itself when both the cue and target word are readily allocated to roles which are complementary in a semantic relation. The mechanisms responsible for role assignment can be facilitated by means of frequency, where noun concepts seem to activate the most frequent integrative relations they are associated with, as well as plausibility, where the pairs must make sense and fit in prior knowledge. In effect, the beneficial effects of the integrative pairs on memory performance of older and younger adults can be viewed as an example of how semantic memory can aid episodic memory. The role assignment model suggests that integrative pairs should be viewed as involving long term/pre-existing knowledge; in order to successfully integrate a pair together, one must possess knowledge of the fact that the words *can* be integrated together and that they make coherent sense when combined. With integrative pairs, people are able to formulate concepts which are consistent with knowledge acquired about the world, facilitating relational processing – or providing the relational framework which makes them more easily encoded and retrieved than the unrelated pairs. The series of experiments conducted in the thesis also demonstrate how the integrative advantage can be reduced; through the employment of an elaborately demanding item-specific task in conjunction with one-by-one presentation of the pairs, as well as by making the assignment of relational roles less useful and specific through the sharing of the same relational roles. As all the pairs called upon the same role assignment, it reduced the usefulness of the specific type of relationship, which the integrative pairs are known promote.

Appendices

Appendix 1 **Experiment 1 Stimuli**

Integrative Cue	Integrative Non-Associative Cue	Unrelated Cue	Target
library	travel	lapel	book
fruit	lemon	affection	cake
soup	tomato	stable	can
birthday	dinner	pillow	candle
race	business	author	car
catholic	town	athlete	church
necklace	factory	stick	diamond
medicine	horse	pub	doctor
guard	apartment	company	dog
velvet	gypsy	cow	dress
tuna	ocean	guide	fish
claw	monkey	campus	foot
herb	shed	towel	garden
halloween	boy	celebration	ghost
jelly	forest	fence	grape
donor	donkey	icing	heart
brass	mouth	light	horn
parade	army	theory	horse
guest	beach	mushroom	house
thesis	student	fall	idea
border	dinosaur	party	land
maple	butterfly	valentine	leaf
government	police	flower	lie
puppy	father	pool	love
sausage	deer	umbrella	meat
breast	strawberry	plumber	milk
copper	chocolate	carrot	money
field	farm	stairway	mouse
denim	linen	estuary	pants
tissue	rice	gear	paper
concert	electric	square	piano
steel	gas	fight	pipe
pilot	corporate	plug	plane
trick	baby	industry	rabbit
acid	summer	food	rain
law	drama	acre	school
beauty	airplane	glass	sleep
cobra	jungle	hat	snake
mountain	road	wick	snow
bathroom	kitchen	island	soap
soccer	winter	termite	sport
false	gold	lecture	teeth
plastic	helicopter	smoke	toy
bottle	box	remote	wine
fireplace	table	chain	wood

Appendix 2

Experiment 1 Univariate ANOVA with co-occurrence (measured by Log Google hits) as the dependent variable and pair type as the fixed factor.

Tests of Between-Subjects Effects

Dependent Variable: Log_Google

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	79.822[a]	2	39.911	52.039	.000	.441
Intercept	3514.846	1	3514.846	4582.975	.000	.972
Pair_type	79.822	2	39.911	52.039	.000	.441
Error	101.235	132	.767			
Total	3695.903	135				
Corrected Total	181.057	134				

a. R Squared = .441 (Adjusted R Squared = .432)

There was a significant difference in co-occurrence between the pair types (F (2, 132) = 52.039, MSE = 39.911, p<.001).

Multiple Comparisons

Dependent Variable: Log_Google

Bonferroni

(I) Pair_type	(J) Pair_type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Integrative Associative	Integrative Non-Associative	.5553*	.18462	.009	.1076	1.0030
	Unrelated	1.8363*	.18462	.000	1.3886	2.2840
Integrative Non-Associative	Integrative Associative	-.5553*	.18462	.009	-1.0030	-.1076
	Unrelated	1.2810*	.18462	.000	.8333	1.7287
Unrelated	Integrative Associative	-1.8363*	.18462	.000	-2.2840	-1.3886
	Integrative Non-Associative	-1.2810*	.18462	.000	-1.7287	-.8333

Based on observed means.

The error term is Mean Square(Error) = .767.

*. The mean difference is significant at the .05 level.

Multiple comparisons with Bonferroni adjustments indicated that the difference in co-occurrence between integrative and integrative non-associative pairs was significant (p = .009), as well as between integrative non-associative and unrelated pairs (p<.001).

Appendix 3 Experiment 1 MRC Psycholinguistic Characteristics

A multivariate ANOVA was performed with pair type as the fixed factor, and brown-verbal frequency (BFRQ), concreteness (CNC), familiarity (FAM), imagability (IMG), Kucera-Francis written frequency (KFFRQ), number of letters (NLET), number of phonemes (NPHN), number of syllables (NSYL), and Thorndike-Lorge written frequency (T-LFRQ) as the dependent variables. The table below shows the mean (and s.d) for each pair type.

	Integrative Associative	Integrative Non-Associative	Unrelated
BFRQ	18.57 (40.84)	24.54 (74.38)	20 (42.74)
CNC	550.52 (77.46)	565.44 (60.84)	556.38 (72.82)
FAM	557.99 (32.55)	566.94 (29.62)	558.83 (27.92)
IMG	568.33 (58.89)	584.63 (47.45)	573.89 (51.98)
KFFRQ	94.14 (147.50)	110.21 (142.97)	101.32 (140.61)
NLET	5.24 (.95)	5.23 (.93)	5.18 (.94)
NPHN	4.11 (.83)	4.23 (1.03)	3.96 (1.14)
NSYL	1.51 (.39)	1.59 (.44)	1.49 (.41)
T-LFRQ	628.01 (705.57)	796.88 (824.3)	690.03 (689.9)

The multivariate ANOVA revealed no significant differences in any of the dependent variables between the pair types:

BFRQ (F (2, 132) = .146, p = .865)

CNC (F (2, 132) = .509, p = .602)

FAM (F (2, 132) = 1.215, p = .300)

IMG (F (2, 132) = 1.101, p = .336)

KFFRQ (F (2, 132) = .141, p = .896)

NLET (F (2, 132) = .065, p = .937)

NPHN (F (2, 132) = .858, p = .426)

NSYL (F (2, 132) = .724, p = .487)

T-LFRQ (F (2, 132) = .596, p = .553)

Pairwise comparisons with Bonferroni adjustments also indicated that the three different pair types did not differ significantly with each other in terms of the different word characteristics (integrative associative vs integrative non associative, integrative associative vs unrelated, and integrative associative vs unrelated).

Appendix 4 **Experiment 2 Stimuli**

Integrative		Unrelated	
Cue	Target	Cue	Target
pool	chair	bottle	necklace
paper	bin	cup	window
rifle	bag	rose	uncle
chocolate	pan	brain	snow
farm	mouse	tear	circle
nurse	school	chart	cottage
desk	plant	chain	wallet
coffee	shirt	bell	helmet
hospital	floor	stable	can
cabinet	cloth	boy	cross
detective	book	umbrella	pencil
horse	doctor	letter	picture
copper	jug	sleeve	apple
food	leaflet	hotel	face
stair	paint	pocket	door
melon	cake	light	horn
sofa	arm	mirror	video
corridor	carpet	ball	powder
prison	bed	wolf	salt
table	wine	bowl	suit

Appendix 5 **Experiment 2 Co-occurrence T-Test**

An independent samples t-test was performed on the co-occurrence data with Log Google hits as the testing variable and pair type as the grouping variable. The table below illustrates the mean and s.d of Log Google hits for the integrative and unrelated pairs.

Group Statistics

	pair_type	N	Mean	Std. Deviation	Std. Error Mean
log_Google	integrative	20	5.0492	.48396	.10822
	unrelated	20	4.8710	.75722	.16932

There was no significant difference in co-occurrence between the integrative and unrelated pairs (t (38) = .887, p = .381).

Appendix 6 Experiment 2 MRC Psycholinguistic Characteristics

An independent t-test was performed with pair type as the grouping variable, and brown-verbal frequency (BFRQ), concreteness (CNC), familiarity (FAM), imagability (IMG), Kucera-Francis written frequency (KFFRQ), number of letters (NLET), number of phonemes (NPHN), number of syllables (NSYL), and Thorndike-Lorge written frequency (T-LFRQ) as the test variables. The table below shows the mean (and s.d) for the integrative and unrelated pairs.

	Integrative	Unrelated
BFRQ	13.90 (16.78)	20.73 (55.08)
CNC	589.13 (19.73)	578.75 (36.03)
FAM	557.88 (32.49)	569.15 (24.42)
IMG	580.98 (27.51)	580.13 (35.33)
KFFRQ	74.78 (59.22)	119 (196.15)
NLET	5.10 (.95)	5.15 (1.00)
NPHN	4.08 (.89)	4 (.79)
NSYL	1.53 (.41)	1.53 (.41)
T-LFRQ	603.30 (347.81)	870.83 (865.10)

The independent t-test revealed no significant differences in any of the test variables between integrative and unrelated pairs:

BFRQ (t (38) = .530, p = .599)

CNC (t (38) = 1.129, p = .266)

FAM (t (38) = 1.240, p = .222)

IMG (t (38) = .085, p = .933)

KFFRQ (t (38) = .965, p = .341)

NLET (t (38) = .162, p = .872)

NPHN (t (38) = .281, p = .780)

NSYL (t (38) = .000, p = 1.000)

T-LFRQ (t (38) = 1.283, p = .207)

Appendix 7 **Experiment 3 Stimuli**

Integrative		Unrelated	
Cue	Target	Cue	Target
rat	nest	pocket	door
table	map	mirror	video
finger	bowl	candle	ring
monkey	foot	light	horn
straw	house	suit	neck
coffee	mouth	hall	lemon
locker	magnet	pen	wine
ball	shed	branch	sink
cash	jar	umbrella	powder
airplane	sleep	autumn	nail
nurse	school	note	blue
summer	movie	dress	home
road	horse	gate	page
string	vest	plate	tax
cabinet	cloth	knight	library
farm	mouse	engine	fox
detective	book	forest	market
water	duck	wolf	cigar
princess	purse	pool	sky
blanket	cupboard	flannel	gold

Appendix 8 **Experiment 3 Co-occurrence T-Test**

An independent samples t-test was performed on the co-occurrence data with Log Google hits for the UK as well as worldwide as the testing variables and pair type as the grouping variable. The table below illustrates the mean and s.d of Log Google UK and worldwide hits for the integrative and unrelated pairs.

Group Statistics

	pair_type	N	Mean	Std. Deviation	Std. Error Mean
log_uk	integrative	20	4.0291	.43746	.09782
	unrelated	20	3.8320	.68615	.15343
log_worldwide	integrative	20	4.7961	.66722	.14920
	unrelated	20	4.8273	.60877	.13613

There was no significant difference in UK co-occurrence ($t\ (38) = 1.083$, $p = .286$) or in worldwide co-occurrence ($t\ (38) = .154$, $p = .878$) between the integrative and unrelated pairs.

Appendix 9 Experiment 3 MRC Psycholinguistic Characteristics

An independent t-test was performed with pair type as the grouping variable, and brown-verbal frequency (BFRQ), concreteness (CNC), familiarity (FAM), imagability (IMG), Kucera-Francis written frequency (KFFRQ), number of letters (NLET), number of phonemes (NPHN), number of syllables (NSYL), and Thorndike-Lorge written frequency (T-LFRQ) as the test variables. The table below shows the mean (and s.d) for the integrative and unrelated pairs.

	Integrative	Unrelated
BFRQ	13.50 (15.52)	9.45 (10.33)
CNC	577.53 (32.38)	569.10 (29.75
FAM	558.53 (26.3)	556.53 (28.73)
IMG	582.73 (26.83)	580.65 (32.77)
KFFRQ	84.58 (87.21)	79.03 (74.93)
NLET	5.2 (1.08)	4.8 (.94)
NPHN	4 (.96)	3.95 (.83)
NSYL	1.43 (.41)	1.4 (.45)
T-LFRQ	535.63 (503.99)	706.98 (862.48)

The independent t-test revealed no significant differences in any of the test variables between integrative and unrelated pairs:

BFRQ (t (38) = .971, p = .338)

CNC (t (38) = .857, p = .397)

FAM (t (38) = .230, p = .820)

IMG (t (38) = .219, p = .828)

KFFRQ (t (38) = .216, p = .830)

NLET (t (38) = 1.250, p = .219)

NPHN (t (38) = .177, p = .861)

NSYL (t (38) = .185, p = .854)

T-LFRQ (t (38) = .767, p = .448)

Appendix 10 **Experiment 4 Stimuli**

Integrative		Unrelated	
Cue	Target	Cue	Target
car	toy	bottle	necklace
ocean	fish	chain	wallet
paper	bin	sleeve	angel
fireplace	shop	letter	picture
rifle	bag	hand	clothes
island	castle	hair	drug
hospital	floor	bell	helmet
costume	box	stable	can
shower	shoes	party	zoo
town	river	pub	file
sofa	arm	boy	cross
wood	fruit	wave	garden
golf	dress	hold	human
knee	doctor	hotel	face
baby	lamp	team	park
rice	spoon	blossom	quilt
earth	walk	brick	milk
money	jacket	tooth	mail
tree	fence	barn	cart
winter	recipe	hammer	college
copper	jug	children	wire
factory	smoke	ball	powder
chocolate	pan	blanket	crown
fridge	beer	pillow	cow
train	bomb	cottage	rubber
tennis	line	throat	night
sea	pebble	plum	triangle
prison	bed	whistle	penny
corridor	carpet	window	medal
war	rose	knife	fan
jungle	bear	phone	grape
camera	spray	lake	chicken
desk	plant	tent	ship
sheep	coat	bridge	wife
melon	cake	menu	storm
feather	shawl	magazine	coal
butcher	gloves	government	dentist
stair	paint	pig	lime
food	leaflet	kettle	cocktail
gun	drawer	woman	barrel

Appendix 11 **Experiment 4 Co-occurrence T-Test**

An independent samples t-test was performed on the co-occurrence data with Log Google hits for the UK as well as worldwide as the testing variables and pair type as the grouping variable. The table below illustrates the mean and s.d of Log Google UK and worldwide hits for the integrative and unrelated pairs.

Group Statistics

	pair_type	N	Mean	Std. Deviation	Std. Error Mean
log_uk	integrative	40	3.8363	.58538	.09256
	unrelated	40	3.5630	.80877	.12788
log_worldwide	integrative	40	4.8679	.51841	.08197
	unrelated	40	4.6273	.67588	.10687

There was no significant difference in UK co-occurrence ($t(78) = 1.731$, $p = .087$) or in worldwide co-occurrence ($t(78) = 1.787$, $p = .078$) between the integrative and unrelated pairs.

Appendix 12 Experiment 4 MRC Psycholinguistic Characteristics

An independent t-test was performed with pair type as the grouping variable, and brown-verbal frequency (BFRQ), concreteness (CNC), familiarity (FAM), imagability (IMG), Kucera-Francis written frequency (KFFRQ), number of letters (NLET), number of phonemes (NPHN), number of syllables (NSYL), and Thorndike-Lorge written frequency (T-LFRQ) as the test variables. The table below shows the mean (and s.d) for the integrative and unrelated pairs.

	Integrative	Unrelated
BFRQ	11.03 (16.05)	15.74 (39.68)
CNC	582.03 (27.39)	573.13 (39.71)
FAM	554.25 (40.93)	553.25 (32.31)
IMG	587.25 (25.56)	582.03 (39.90)
KFFRQ	63.59 (56.89)	100.88 (151.2)
NLET	4.95 (.90)	5.2 (1.09)
NPHN	3.91 (.92)	4.15 (1.02)
NSYL	1.51 (.43)	1.5 (.42)
T-LFRQ	574.56 (391.23)	672.46 (752.53)

The independent t-test revealed no significant differences in any of the test variables between integrative and unrelated pairs:

BFRQ (t (78) = .696, p = .488)

CNC (t (78) = 1.167, p = .247)

FAM (t (78) = .121, p = .904)

IMG (t (78) = .697, p = .488)

KFFRQ (t (78) = 1.460, p = .148)

NLET (t (78) = 1.116, p = .268)

NPHN (t (78) = 1.094, p = .277)

NSYL (t (78) = .131, p = .896)

T-LFRQ (t (78) = .730, p = .468)

Appendix 13 **Experiment 5 Stimuli**

All pairs were presented in the study phase, with the exception of the bold pairs, which were presented as new pairs in the recognition phase.

Integrative Shared List 1		Integrative Shared List 2		Integrative Shared List 3		Integrative Shared List 4	
Cue	Target	Cue	Target	Cue	Target	Cue	Target
squirrel	nose	mountain	fly	cotton	socks	titanium	spoon
donkey	face	river	worm	silk	underwear	steel	fork
dog	eyes	valley	spider	polyester	bra	nickel	bowl
cat	brain	hill	cockroach	lace	blouse	aluminium	tongs
horse	head	rock	beetle	leather	shorts	iron	ladle
lion	teeth	tree	moth	linen	skirt	gold	spatula
bear	mouth	cave	wasp	fleece	sweater	platinum	pot
cow	stomach	island	butterfly	velvet	gloves	lead	knife
deer	heart	cliff	bee	cashmere	hat	bronze	pan
giraffe	liver	dirt	bug	cloth	scarf	brass	cup
goat	bones	grass	centipede	satin	jeans	zinc	whisk
zebra	ear	canyon	caterpillar	nylon	boxers	magnesium	colander
tiger	**leg**	**beach**	**ant**	**spandex**	**dress**	**silver**	**blender**
elephant	**foot**	**dessert**	**flea**	**denim**	**coat**	**copper**	**plate**
rabbit	**neck**	**lake**	**mosquito**	**wool**	**shirt**	**tin**	**stove**

Unrelated Shared List 1		Unrelated Shared List 2		Unrelated Shared List 3		Unrelated Shared List 4	
Cue	Target	Cue	Target	Cue	Target	Cue	Target
apple	rap	eagle	salt	athlete	tornado	gun	carrot
pear	rock	robin	pepper	teacher	drought	sword	lettuce
banana	classical	hawk	garlic	lawyer	rain	bat	broccoli
tangerine	country	crow	sugar	student	snow	fist	cucumber
orange	jazz	parrot	nutmeg	professor	hail	stick	peas
mango	soul	sparrow	spice	fireman	flood	arrow	corn
strawberry	punk	pigeon	vanilla	janitor	lightning	rope	potato
kiwi	gospel	seagull	thyme	dentist	blizzard	axe	squash
pineapple	blues	dove	ketchup	engineer	sun	grenade	spinach
watermelon	dance	falcon	butter	secretary	monsoon	missile	celery
apricot	pop	owl	basil	manager	sleet	pistol	bean
peach	reggae	ostrich	mustard	cook	wind	hammer	cabbage
cherry	**opera**	**penguin**	**onion**	**banker**	**thunder**	**blade**	**turnip**
raspberry	**folk**	**flamingo**	**cinnamon**	**carpenter**	**storm**	**spear**	**radish**
nectarine	**techno**	**vulture**	**vinegar**	**scientist**	**cloud**	**bazooka**	**asparagus**

Integrative Unique		Integrative Unique		Unrelated Unique		Unrelated Unique	
Cue	Target	Cue	Target	Cue	Target	Cue	Target
car	toy	train	bomb	bottle	necklace	cottage	rubber
ocean	fish	tennis	line	chain	wallet	throat	night
paper	bin	sea	pebble	sleeve	angel	plum	triangle
fireplace	shop	prison	bed	letter	picture	whistle	penny
rifle	bag	corridor	carpet	hand	clothes	window	medal
cash	jar	war	rose	hair	drug	wolf	cigar
hospital	floor	summer	movie	bell	helmet	phone	grape
costume	box	camera	spray	stable	can	pen	wine
shower	shoes	desk	plant	party	zoo	tent	ship
table	map	sheep	fence	pub	file	bridge	wife
sofa	arm	melon	cake	boy	cross	menu	truck
wood	fruit	feather	shawl	wave	brush	magazine	coal
golf	chair	butcher	trolley	hold	human	government	lie
knee	doctor	stair	paint	mirror	video	pig	lime
baby	lamp	food	leaflet	team	park	kettle	cocktail
rice	dish	metal	drawer	blossom	quilt	woman	barrel
earth	walk	rat	nest	brick	milk	pocket	door
money	jacket	nurse	school	tooth	mail	candle	ring
locker	magnet	straw	house	barn	cart	umbrella	powder
winter	recipe	string	vest	boot	college	autumn	nail
glass	jug	ball	shed	children	wire	forest	market
factory	smoke	farm	mouse	chart	king	pool	sky
chocolate	sponge	detective	book	blanket	crown	branch	sink
fridge	beer	airplane	sleep	light	horn	gate	page
kangaroo	**meat**	**jungle**	**snake**	**pillow**	**envelope**	**engine**	**fox**
corporate	**plane**	**kitchen**	**soap**	**trailer**	**plug**	**suit**	**home**
gas	**pipe**	**water**	**duck**	**tear**	**circle**	**trophy**	**clown**
electric	**piano**	**princess**	**purse**	**hall**	**lemon**	**chicken**	**pole**
dinosaur	**land**	**tomato**	**garden**	**note**	**blue**	**bank**	**drum**
father	**love**	**army**	**flag**	**knight**	**library**	**mug**	**leaves**

Appendix 14 Experiment 5 Co-occurrence with Univariate ANOVA

A univariate ANOVA was conducted with co-occurrence (measured by Log Google hits) as the dependent variable and pair type as the fixed factor.

Tests of Between-Subjects Effects

Dependent Variable: log_google

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	171.398[a]	3	57.133	85.077	.000
Intercept	4501.199	1	4501.199	6702.782	.000
pair_type	171.398	3	57.133	85.077	.000
Error	158.484	236	.672		
Total	4831.081	240			
Corrected Total	329.882	239			

a. R Squared = .520 (Adjusted R Squared = .513)

There was a significant difference in co-occurrence between the pair types ($F(3, 236) = 85.077$, MSE = 57.133, $p<.001$).

Multiple Comparisons

Dependent Variable: log_google
Bonferroni

(I) pair_type	(J) pair_type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
integrative_shared	unrelated_shared	1.6181*	.14962	.000	1.2200	2.0161
	integrative_unique	-.5718*	.14962	.001	-.9699	-.1737
	unrelated_unique	-.2584	.14962	.513	-.6564	.1397
unrelated_shared	integrative_shared	-1.6181*	.14962	.000	-2.0161	-1.2200
	integrative_unique	-2.1899*	.14962	.000	-2.5879	-1.7918
	unrelated_unique	-1.8764*	.14962	.000	-2.2745	-1.4783
integrative_unique	integrative_shared	.5718*	.14962	.001	.1737	.9699
	unrelated_shared	2.1899*	.14962	.000	1.7918	2.5879
	unrelated_unique	.3135	.14962	.223	-.0846	.7115
unrelated_unique	integrative_shared	.2584	.14962	.513	-.1397	.6564
	unrelated_shared	1.8764*	.14962	.000	1.4783	2.2745
	integrative_unique	-.3135	.14962	.223	-.7115	.0846

Based on observed means.
The error term is Mean Square(Error) = .672.

*. The mean difference is significant at the .05 level.

Multiple comparisons with Bonferroni adjustments indicated that the difference in co-occurrence was significant between integrative shared and unrelated shared pairs ($p<.001$), between integrative shared and integrative unique pairs ($p<.001$), between unrelated shared and integrative unique pairs ($p<.001$), and between unrelated shared and unrelated unique pairs ($p<.001$). However, it was not significant between integrative shared and unrelated unique pairs ($p = .513$), or between integrative unique and unrelated unique pairs ($p = .223$). The means (and sds) are displayed below:

Descriptive Statistics

Dependent Variable: log_google

pair_type	Mean	Std. Deviation	N
integrative_shared	4.5277	1.00959	60
unrelated_shared	2.9096	.95021	60
integrative_unique	5.0995	.49344	60
unrelated_unique	4.7860	.72146	60
Total	4.3307	1.17484	240

Appendix 15 Experiment 5 MRC Psycholinguistic Characteristics

A multivariate ANOVA was performed with pair type as the fixed factor, and brown-verbal frequency (BFRQ), concreteness (CNC), familiarity (FAM), imagability (IMG), Kucera-Francis written frequency (KFFRQ), number of letters (NLET), number of phonemes (NPHN), number of syllables (NSYL), and Thorndike-Lorge written frequency (T-LFRQ) as the dependent variables. The table below shows the mean (and s.d) for each pair type.

	Integrative Shared	Unrelated Shared	Integrative Unique	Unrelated Unique
BFRQ	8.09 (7.61)	8.13 (10.58)	12.68 (16.28)	14.43 (33.82)
CNC	588.39 (25.9)	580.21 (58.16)	580.30 (34.71)	575.51 (33.29)
FAM	543.23 (45.05)	543.86 (36.22)	554.88 (34.57)	553.04 (31.52)
IMG	581.30 (39.67)	573.64 (49.43)	585.43 (26.68)	578.83 (39.30)
KFFRQ	69.98 (60.35)	65.25 (75.55)	70.88 (67.51)	78.53 (123.76)
NLET	5.27 (1.13)	5.45 (1.07)	5.1 (1.06)	5.08 (.98)
NPHN	4.23 (1.18)	4.41 (.93)	4.06 (1.03)	4.08 (.86)
NSYL	1.56 (.52)	1.66 (.42)	1.53 (.46)	1.46 (.43)
T-LFRQ	370.69 (503.20)	205.52 (280.72)	594.53 (631.98)	622.9 (732.91)

The multivariate ANOVA revealed no significant differences in any of the dependent variables between the pair types, except for Thorndike-Lorge written frequency:

BFRQ (F (3, 236) = 1.578 p = .195)

CNC (F (3, 236) = 1.079, p = .359)

FAM (F (3, 236) = 1.597, p = .191)

IMG (F (3, 236) = .929, p = .427)

KFFRQ (F (3, 236) = .248, p = .863)

NLET (F (3, 236) = 1.609, p = .188)

NPHN (F (3, 236) = 1.539, p = .205)

NSYL (F (3, 236) = 1.961, p = .121)

T-LFRQ (F (3, 236) = 7.368, p<.001)

Pairwise comparisons with Bonferroni adjustments also indicated that the four different pair types did not differ significantly with each other in terms of the different word characteristics, except for Thorndike-Lorge written frequency where integrative shared pairs differed significantly from integrative unique pairs (p = .030), integrative shared pairs differed from unrelated unique pairs (p = .015), unrelated shared pairs differed from integrative unique pairs (p<.001), and unrelated shared pairs differed from unrelated unique pairs (p<.001). However, the integrative shared pairs did not differ significantly from the unrelated shared pairs in the Thorndike-Lorge written frequency (p = .110), nor did the integrative unique pairs differ significantly from the unrelated unique pairs (p = .783).

Bibliography

Addis, D.R., Giovanello, K.S., Vu, M.A., & Schacter, D.L. (2014). Age-related changes in prefrontal and hippocampal contributions to relational encoding. *NeuroImage*, 84, 19-26

Ahmad, F.N., Fernandes, M., & Hockley, W.E. (2015). Improving associative memory in older adults with unitization. *Aging, Neuropsychology, and Cognition*, 22 (4), 452-472

Anderson, J.R. (1974). Retrieval of propositional information from long-term memory. *Cognitive Psychology*, 6 (4), 451-474

Badham, S.P., Estes, Z., & Maylor, E.A. (2012). Integrative and semantic relations equally alleviate age-related associative memory deficits. *Psychology and Aging*, 27 (1), 141-152

Badham, S.P., & Maylor, E.A. (2015). What you know can influence what you are going to know (especially for older adults). *Psychonomic Bulletin Review*, 22 (1), 141-146

Bastin, C., & Van der Linden, M. (2003). The contribution of recollection and familiarity to recognition memory: A study of the effects of test format and aging. *Neuropsychology*, 17 (1), 14-24

Begg, I. (1972). Recall of meaningful phrases. *Journal of Verbal Learning and Verbal Behaviour*, 11 (4), 431-439

Bender, A.R., & Raz, N. (2012). Age-related differences in recognition memory for items and associations: Contribution of individual differences in working memory and metamemory. *Psychology and Aging*, 27 (3), 691-700

Besken, M., & Gulgoz, S. (2009). Relaince on schemes in source memory: Age differences and similarity of schemas. *Aging, Neuropsychology, and Cognition*, 16 (1), 1-21

Bireta, T.J., Surprenant, A.M., & Neath, I. (2008). Age-related differences in the von Restorff isolation effect. *Quarterly Journal of Experimental Psychology*, 61 (3), 1-8

Brown, C., & Lloyd-Jones, T.J. (2006). Beneficial effects of verbalization and visual distinctiveness on remembering and knowing faces. *Memory & Cognition*, 34 (2), 277-286

Castel, A.D. (2005). Memory for grocery prices in younger and older adults: The role of schematic support. *Psychology and Aging*, 20 (4), 718-721

Castel, A.D., McGillivray, S., & Worden, K.M. (2013). Back to the future: Past, and future era-based schematic support and associative memory for prices in younger and older adults. *Psychology and Aging*, 28 (4), 996-1003

Chalfonte, B.I., & Johnson, M.K. (1996). Feature memory and binding in young and older adults. *Memory and Cognition*, 24 (4), 403-416

Cohn, M., & Moscovitch, M. (2007). Dissociating measures of associative memory: Evidence and theoretical implications. *Journal of Memory and Language*, 57 (3), 437-454

Cohn, M., Emrich, S.M., & Moscovitch, M. (2008). Age-related deficits in associative memory: The influence of impaired strategic retrieval. *Psychology and Aging*, 23 (1), 93-103

Collins, A., & Michalski, R. (1989). The logic of plausible reasoning: A core theory. *Cognitive Science*, 13 (1), 1-49

Connell, L., & Keane, M.T. (2006). A model of plausibility. *Cognitive Science*, 30 (1), 95-120

Cooper, C.M., & Odegard, T.M. (2012). Influence of recollection and plausibility on age-related deficits in associative memory. *Memory*, 20 (1), 28-36

Costello, F.J., & Keane, M.T. (2000). Efficient creativity: Constraint-guided conceptual combination. *Cognitive Science*, 24 (2), 299-349

Craik, F.I.M. (1977). Age differences in human memory. In J.E. Birren & K.W. Schaie (Eds.) *Handbook of the Psychology of Aging*, (pp.384-420). New York, NY: Van Nostrand Reinhold

Craik, F.I.M. (1979). Levels of processing: Overview and closing comments. In L.S. Cermak & F.I.M. Craik (Eds.) *Levels of Processing and Human Memory* (pp.447-461). Hillsdale, NJ: Lawrence Erlbaum Associates

Craik, F.I.M. (1986). A functional account of age differences in memory. In F. Klix & H. Hagendorf (Eds.) *Human Memory and Cognitive Capabilities: Mechanisms and Performances* (pp.409-422). Amsterdam, North-Holland: Elsevier Science Publishing Company

Craik, F.I.M. (2002). Human memory and aging. In L. Backman & C. von Hofsten (Eds.) *Psychology at the Turn of the Millennium*. (pp.261-280). Hove; UK: Psychology Press

Craik, F.I.M., & Lockhart, R.S. (1972). Levels of processing: A framework for memory research. *Journal of Verbal Learning and Verbal Behaviour*, 11 (6), 671-684

Craik, F.I.M., & Byrd, M. (1982). Aging and cognitive deficits: The role of attentional resources. In F.I.M. Craik & S.E. Trehub (Eds.). *Aging and Cognitive Processes*. (pp.191-211). New York: Plenum

Craik, F.I.M., & McDowd, J.M. (1987). Age differences in recall and recognition. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 13 (3), 474-479

Craik, F.I.M., Morris, L.W., Morris, R.G., & Loewen, E.R. (1990). Relations between source amnesia and frontal lobe functioning in older adults. *Psychology and Aging*, 5 (1), 148-151

Craik, F.I.M., & Dirkx, E. (1992). Age-related differences in three tests of visual imagery. *Psychology and Aging*, 7 (4), 661-665

Craik, F.I.M., & Jennings, J.M. (1992). Human memory. In F.I.M. Craik & T.A. Salthouse (Eds.) *The Handbook of Ageing and Cognition*. (pp. 51-110). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc

Craik, F.I.M., & Rose, N.S. (2012). Training cognition: Parallels with physical fitness? *Journal of Applied Research in Memory and Cognition*, 1 (1), 51-52

Davis, H.P., & Bernstein, P.A. (1992). Age-related changes in explicit and implicit memory. In L.R. Squire & N. Butters (Eds.). *Neuropsychology of Memory*, (pp. 249-261)

Dew, I.T.Z., & Giovanello, K.S. (2010). Differential age effects for implicit and explicit conceptual associative memory. *Psychology and Aging*, 25 (4), 911-921

Dirkx, E., & Craik, F.I.M. (1992). Age-related differences in memory as a function of imagery processing. *Psychology and Aging*, 7 (3), 352-358

Doumas, L.A.A., Hummel, J.E., & Sandhofer, C.M. (2008). A theory of the discovery and predication of relational concepts. *Psychological Review*, 115 (1), 1-43

Dror, I.E., & Kosslyn, S.M. (1994). Mental imagery and aging. *Psychology and Aging*, 9 (1), 90-102

Dunlosky, J., Hertzog, C., & Powell-Moman, A. (2005). The contribution of mediator-based deficiencies to age differences in associative learning. *Developmental Psychology*, 41 (2), 389-400

Einstein, G.O., & Hunt, R.R. (1980). Levels of processing and organization: Additive effects of individual-item and relational processing. *Journal of Experimental Psychology: Human Learning and Memory*, 6 (5), 588-598

Einstein, G.O., McDaniel, M.A., Bowers, C.A., & Stevens, D.T. (1984). Memory for prose: The influence of relational and proposition-specific encoding. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 10 (1), 133-143

Epstein, M.L., Phillips, W.D., & Johnson, S.J. (1975). Recall of related and unrelated word pairs as a function of processing level. *Journal of Experimental Psychology: Human Learning and Memory*, 104 (2), 149-152

Erber, J.T., Galt, D.J., & Botwinick, J. (1985). Age differences in the effects of contextual framework and word-familiarity on episodic memory. *Experimental Aging Research*, 11 (2), 101-103

Estes, Z. (2003). A tale of two similarities: Comparison and integration in conceptual combination. *Cognitive Science*, 27 (6), 911-921

Estes, Z., & Glucksberg, S. (2000). Interactive property attribution in conceptual combination. *Memory and Cognition*, 28 (1), 28-34

Estes, Z., & Jones, L.L. (2009). Integrative priming occurs rapidly and uncontrollably during lexical processing. *Journal of Experimental Psychology: General*, 138 (1), 112-130

Fastenau, P.S., Denburg, N.L., & Abeles, N. (1996). Age differences in retrieval: Further support for the resource-reduction hypothesis. *Psychology and Aging*, 11 (1), 140-146

Ferretti, T.R., Kutas, M., & McRae, K. (2007). Verb aspect and the activation of event knowledge. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 33 (1), 182-196

Fisher, L.M., & McDowd, J.M. (1993). Item and relational processing in young and older adults. *Journal of Gerontology: Psychological Sciences*, 48 (2), 62-68

Folstein, M.F., & Folstein, S.E. (2010). Mini-mental state examination, 2nd edition. Ann Arbor Publishers

Fox, M.C., Baldock, Z., Freeman, S.P., & Berry, J.M. (2016). The role of encoding strategy in younger and older adult associative recognition: A think-aloud analysis. *Psychology and Aging*, 31 (5), 471-480

Fuentes, A., & Desrocher, M. (2013). The effects of gender on the retrieval of episodic and semantic components of autobiographical memory. *Memory*, 21 (6), 619-632

Gaigg, S.B., Gardiner, J.M., & Bowler, D.M. (2008). Free recall in autism spectrum disorder: The role of relational and item-specific encoding. *Neuropsychologia*, 46 (4), 983-992

Geraci, L., & Barnhardt, T.M. (2010). Aging and implicit memory: Examining the contribution of test awareness. *Consciousness and Cognition*, 19 (2), 606-616

Glenberg, A.M., & Bradley, M.M. (1979). Mental contiguity. *Journal of Learning and Memory,* 5 (2), 88-97

Glucksberg, S. & Estes, Z. (2000). Feature accessibility in conceptual combination: Effects of context-induced relevance. *Psychonomic Bulletin & Review,* 7, 510-515

Hannon, B., & Craik, F.I.M. (2001). Encoding specificity revisited: The role of semantics. *Canadian Journal of Experimental Psychology*, 55 (3), 231-243

Hartman, M., & Warren, L.H. (2005). Explaining age differences in temporal working memory. *Psychology and Aging*, 20 (4), 645-656

Hasher, L., Zacks, R.T., & May, C.P. (1999). Inhibitory control, circadian arousal, and age. In D. Gopher & A. Koriat (Eds.) *Attention and Performance*, (pp.653-675). Cambridge, MA: MIT Press

Hoyer, W.J., & Verhaeghen, P. (2006). Memory aging. In J.E. Birren and K.W. Schaie (Eds.), *Handbook of the Psychology of Aging, Sixth Edition*, (pp.209-232). San Diego: Elsevier

Hubbard, N.A., Hutchison, J.L., Turner, M., Montroy, J., Bowles, R.P., & Rypma, B. (2016). Depressive thoughts limit working memory capacity in dysphoria. *Cognition and Emotion,* 30 (2), 193-209

Hultsch, D.F. (1969). Adult age differences in the organization of free recall. *Developmental Psychology*, 1 (6), 673-678

Hunt, R.R. (2006). The concept of distinctiveness in memory research. In R.R. Hunt & J.B. Worthen (Eds.). *Distinctiveness and Memory* (pp. 4-26). Oxford University Press

Hunt, R.R., & Einstein, G.O. (1981). Relational and item-specific information in memory. *Journal of Verbal Learning and Verbal Behaviour*, 20 (5), 497-514

Hunt, R.R., & Seta, C.E. (1984). Category size effects in recall – the roles of relational and individual item information. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 10 (3), 454-464

Hunt, R.R., & McDaniel, M.A. (1993). The enigma of organization and distinctiveness. *Journal of Memory and Language*, 32 (4), 421-445

Ikier, S., & Hasher, L. (2006). Age differences in implicit interference. *Journal of Gerontology: Psychological Sciences*, 61 (5), 278-284

Jacoby, L.L (1999). Ironic effects of repetition: Measuring age-related differences in memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 25 (1), 3-22

Jones, M., & Love, B.C. (2007). Beyond common features: The role of roles in determining similarity. *Cognitive Psychology*, 55 (3), 196-231

Jones, L.L., Estes, Z., & Marsh, R.L. (2008). An asymmetric effect of relational integration on recognition memory. *The Quarterly Journal of Experimental Psychology*, 61 (8), 1169-1176

Kang, S.H.K. (2010). Enhancing visuospatial learning: The benefit of retrieval practice. *Memory and Cognition*, 38 (8), 1009-1017

Karpicke, J.D., & Smith, M.A. (2012). Separate mnemonic effects of retrieval practice and elaborative encoding. *Journal of Memory and Language*, 67 (1), 17-29

Kensinger, E.A., & Schacter, D.L. (1999). When true memories suppress false memories: Effects of ageing. *Cognitive Neuropsychology*, 16 (3-5), 399-415

Koutmeridou, K. (2013). Memory as discrimination: Strategic processing of retrieval cues, (unpublished doctoral thesis, City, University of London).

Koutstaal, W., & Schacter, D.L. (1997). Gist-based false recognition of pictures in older and younger adults. *Journal of Memory and Language*, 37 (4), 555-583

Kuhlmann, B.G., & Touron, D.R. (2012). Mediator-based encoding strategies in source monitoring in young and older adults. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 38 (5), 1352-1364

Lemaire, P., Arnaud, L., & Lecacheur, M. (2004). Adults' age-related differences in adaptivity of strategy choices: Evidence from computational estimation. *Psychology and Aging*, 19 (3), 467-481

Lerner, I., Bentin, S., & Shriki, O. (2012). Spreading activation in an attractor netwoek with latching dynamics: Automatic semantic priming revisited. *Cognitive Science,* 36 (8), 1339-1382

Light, L.L., Prull, M.W., LaVoie, D.J., & Healy, M.R. (2000). Dual-process theories of memory in old age. In T.J. Perfect & E.A. Maylor (Eds.). *Models of Cognitive Aging* (pp. 238-300) New York: Oxford University Press

Lindenberger, U., Marsiske, M., & Baltes, P.B. (2000). Memorizing while walking: Increase in dual-task costs from young adulthood to old age. *Psychology and Aging*, 15 (3), 417-436

Luszcz, M.A., Roberts, T.H., & Mattiske, J. (1990). Use of relational and item-specific information in remembering by older and younger adults. *Psychology and Aging*, 5 (2), 242-249

Lyle, K.B., Bloise, S.M., & Johnson, M.K. (2006). Age-related binding deficits and the content of false memories. *Psychology and Aging*, 21 (1), 86-95

Masson, M.E.J. (1995). A distributed memory model of semantic priming. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 21 (1), 3-23

Mata, R., Schooler, L.J., & Rieskamp, J. (2007). The aging decision maker: Cognitive aging and the adaptive selection of decision strategies. *Psychology and Aging*, 22 (4), 796-810

Mather, E., Jones, L.L., & Estes, Z. (2014). Priming by relational integration in perceptual identification and Stroop colour naming. *Journal of Memory and Language*, 71 (1), 57-70

Maylor, E.A., & Henson, R.N.A. (2000). Aging and the Ranschburg effect: No evidence of reduced response suppression in old age. *Psychology and Aging*, 15 (4), 657-670

McDaniel, M.A., & Einstein, G.O. (1986). Bizarre imagery as an effective memory aid: The importance of distinctiveness. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 12 (1), 54-65

McGillivray, S., & Castel, A.D. (2010). Memory for age-face associations in younger and older adults: The role of generation and schematic support. *Psychology and Aging*, 25 (4), 822-832

Mitchell, K.J., Johnson, M.K., Raye, C.L., Mather, M., & D'Esposito, M. (2000). Aging and reflective processes of working memory: Binding and test load deficits. *Psychology and Aging*, 15 (3), 527-541

Mohanty, P.P., Naveh-Benjamin, M., & Ratneshwar, S. (2016). Beneficial effects of semantic memory support on older adults' episodic memory: Differential patterns of support of item and associative information. *Psychology and Aging*, 31 (1), 25-36

Moscovitch, M. (1992). Memory and working with memory: A component process model based on modules and control systems. *Journal of Cognitive Neuroscience*, 4 (3), 257-267

Moscovitch, M., & Craik, F.I.M. (1976). Depth of processing, retrieval cues and uniqueness of encoding as factors in recall. *Journal of Verbal Learning and Verbal Behaviour*, 15 (4), 447-458

Naveh-Benjamin, M. (2000). Adult age differences in memory performance: Tests of an associative deficit hypothesis. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 26 (5), 1170-1187

Naveh-Benjamin, M., Craik, F.I.M., & Ben-Shaul, L. (2002). Age-related differences in cued recall: Effects of support at encoding and retrieval. *Aging, Neuropsychology, and Cognition*, 9 (4), 276-287

Naveh-Benjamin, M., Hussain, Z., Guez, J., & Bar-On, M. (2003). Adult age differences in episodic memory: Further support for an associative-deficit hypothesis. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 29 (5), 826-837

Naveh-Benjamin, M., Guez, J., Kilb, A., & Reedy, S. (2004). The associative memory deficit of older adults: Further support using face-name associations. *Psychology and Aging*, 19 (3), 541-546

Naveh-Benjamin, M., Brav, T.K., & Levy, O. (2007). The associative memory deficit of older adults: The role of strategy utilization. *Psychology and Aging*, 22 (1), 202-208

Naveh-Benjamin, M., Shing, Y.L., Kilb, A., Werkle-Bergner, M., & Lindenberger, U. (2009). Adult age differences in memory for name-face associations: The effects of intentional and incidental learning. *Memory*, 17 (2), 220-232

Naveh-Benjamin, M., Maddox, G., Jones, P., Old, S., & Kilb, A. (2012). The effects of emotional valence and gender on the associative memory deficit of older adults. *Memory and Cognition*, 40 (4), 551-555

Nelson, D.L., & Brooks, D.H. (1974). Relative effectiveness of rhymes and synonyms as retrieval cues. *Journal of Experimental Psychology*, 102 (3), 503-507

Nelson, D.L., McEvoy, C.L., & Schreiber, T.A. (1998). The University of South Florida word association, rhyme, and word fragment norms. http://www.usf.edu/FreeAssociation/

Odegard, T.N., Koen, J.D., & Gama, J.M. (2008). Process demands of rejection mechanisms of recognition memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 34 (5), 1296-1304

Overman, A.A., & Becker, J.T. (2009). The associative deficit in older adult memory: Recognition of pairs is not improved by repetition. *Psychology and Aging*, 24 (2), 501-506

Patterson, M.M., & Hertzog, C. (2010). The effects of age in four alternative forced choice item and associative recognition tasks. *Psychology and Aging*, 25 (1), 235-238

Prull, M.W., Dawes, L.L., Martin, A.M., Rosenberg, H.F., & Light, L.L. (2006). Recollection and familiarity in recognition memory: Adult age differences and neuropsychological test correlates. *Psychology and Aging*, 21 (1), 107-118

Rabinowitz, J.C. (1986). Priming in episodic memory. *Journal of Gerontology*, 41 (2), 204-213

Rabinowitz, J.C., Craik, F.I.M., & Ackerman, B.P. (1982). A processing resource account of age differences in recall. *Canadian Journal of Psychology*, 36 (2), 325-344

Rankin, J.L., & Firnhaber, S. (1986). Adult age differences in memory: Effects of distinctive and common encodings. *Experimental Aging Research*, 12 (3), 141-146

Rogers, W.A., Hertzog, C., & Fisk, A.D. (2000). An individual differences analysis of ability and strategy influences: Age-related differences in associative learning. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 26 (2), 359-394

Ryan, J.D., Leung, G., Turk-Browne, N.B., & Hasher, L. (2007). Assessment of age-related changes in inhibition and binding using eye movement monitoring. *Psychology and Aging*, 22 (2), 239-250

Salthouse, T.A. (2010). Selective review of cognitive aging. *Journal of the International Neuropsychological Society*, 16 (5), 754-760

Smith, R.E. (2006). Adult age differences in episodic memory: Item-specific, relational and distinctive processing. In R.R. Hunt & J.B. Worthen (Eds.). *Distinctiveness and Memory*. (pp. 260-282). Oxford University Press

Smith, R.E., Hunt, R.R., & Dunlosky, J. (2005). Aging, distinctive processing, and recall: An investigation using participant generated cues. *Manuscript under review*

Thomas, A.K., & Sommers, M.S. (2005). Attention to item-specific processing eliminates age effects in false memories. *Journal of Memory and Language*, 52 (1), 71-86

Tournier, I., & Postal, V. (2011). Strategy selection and aging: Impact of item concreteness in paired-associate task. *Aging, Neuropsychology, and Cognition*, 18 (2), 195-213

Tulving, E. (1972). Episodic and semantic memory. In E. Tulving & W. Donaldson (Eds.), *Organization of Memory*, (pp. 381-403), New York: Academic Press

Uittenhove, K., Burger, L., Taconnat, L., & Lemaire, P. (2015). Sequential difficulty effects during execution of memory strategies in young and older adults. *Memory*, 23 (6), 806-816

Umanath, S., & Marsh, E.J. (2014). Understanding how prior knowledge influences memory in older adults. *Perspectives on Psychological Science*, 9 (4), 408-426

Van Overschelde, J.P., Rawson, K.A., & Dunlosky, J. (2004). Category norms: An updated and expanded version of the Battig and Montague (1969) norms. *Journal of Memory and Language*, 50 (3), 289-335

VanWormer, L.A., Bireta, T.J., Surprenant, A.M., & Neath, I. (2012). The effect of perceptual cues on inhibiting irrelevant information in older adults using a list-learning method. *Experimental Aging Research*, 38 (3), 279-294

Ward, E.V., Berry, C.J., & Shanks, D.R. (2013). Age effects on explicit and implicit memory. *Frontiers in Psychology*, Vol 4, Article 639, 1-11

Watkins, O.C., & Watkins, M.J. (1975). Build-up of proactive inhibition as a cue overload effect. *Journal of Experimental Psychology: Human Learning and Memory*, 1 (4), 442-452

Wechsler, D. (1999). Wechsler Abbreviated Scale of Intelligence. *The Psychological Corporation, San Antonio, TX*

West, R., & Alain, C. (2000). Age-related decline in inhibitory control contributes to the increased Stroop effect observed in older adults. *Psychophysiology*, 37 (2), 179-189

Wilson, M.D. (1988). The MRC Psycholinguistic Database: Machine Readable Dictionary, Version 2. *Behavioural Research Methods, Instruments, and Computers*, 20 (1), 6-11

Wisniewski, E.J., & Murphy, G.L. (2005). Frequency of relation type as a determinant of conceptual combination: A reanalysis. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 31 (1), 169-174

Zacks, R.T., Hasher, L., & Li, K.Z.H. (2000). Human memory. In T.A. Salthouse & F.I.M. Craik (Eds.), *Handbook of Aging and Cognition*, *2nd Edition*, (pp.293-357). Mahwah, NJ: Lawrence Erlbaum