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Age Differences in Implicit Memory Tests

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Abstract

Evidence concerning age differences on perceptual implicit memory tests has been inconsistent, with some studies showing no age effects and others showing reduced priming in older adults. Recently, research on implicit tests that focus more on the semantic features of words has typically shown no reliable age effect on priming scores. In the present study we examined the pattern of age effects on a conceptual (general knowledge) and a perceptual (word stem completion) implicit test. Explicit memory performance was measured using cued word recall and fact recall tests. The nature of the encoding task used for each test was also manipulated in order to examine levels of processing effects. Young, middle age and older adults were tested to determine if any significant age differences would be found on the memory tests. Significant age differences were found on both the word stem completion and general knowledge tests, even though all age groups demonstrated significant priming on these tests. The explicit test of cued word recall also demonstrated significant age differences, yet fact recall failed to produce significant age effects. A reverse depth effect was found on the general knowledge and cued word recall tests. Based on the results it was concluded that age differences exist on both perceptual and conceptual implicit memory tests.

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Age Differences in Implicit Memory Tests

Interest in implicit tests of memory has increased in recent years. These are tests of memory for a prior event, although often no reference is made to the prior event in the test instructions. Memory is revealed as a change in test performance that is attributable to exposure to the prior event (for reviews, see Richardson-Klavehn & Bjork, 1988; Roediger & McDermott, 1993). A typical implicit memory test involves a study phase in which participants are exposed to a list of words, with instructions to perform some specific encoding task on the words. After the study trial the participant completes the test phase. There are several different types of implicit memory tests, one of the most common of which is word stem completion.

In the word stem completion test, participants are first presented with words in a study phase (turkey), and are later asked to complete three letter word stems (tur___), with the first word that comes to mind. Thus, this is an implicit memory task because the participant is not asked for conscious recollection of a prior event, but is simply asked to give the first response that comes to mind. Memory is assessed by comparing the likelihood that a word studied before is used to complete a stem to the likelihood that it is used by a person who has not studied the word. What is interesting about implicit memory studies is that performance has often been found to be dissociated from performance on tests of episodic memory (Roediger & McDermott, 1993).

Implicit memory tests are often compared to explicit memory tests which require the participant to think back to a previous study phase and consciously recall the words that were presented. For example, in a free recall test, participants are presented with a blank sheet of paper and told to write down any words that they remember from the study phase. Unlike implicit memory

tests, the participants are specifically reminded of the study phase. Another type of explicit memory test involves providing a cue to the participant in order to recall the material. For example, in cued word recall the first 3 letters of the studied word may be presented at test. The implicit test of word stem completion and this explicit test of cued word recall are identical except that the instructions are varied. To summarize, implicit memory tests make no reference to the study phase nor do they mention any form of intentional retrieval. On the other hand, explicit memory tests directly refer to the study period.

Dissociations Between Implicit and Explicit Tests

The literature has focused on determining what processes underlie implicit and explicit memory performance by studying dissociations between performance on different tests. A dissociation occurs when an independent variable is manipulated and the subject's performance on the two types of tests is affected differently.

Several studies have shown that performance on implicit and explicit memory tests can be dissociated (for review, see Richardson-Klavehn & Bjork, 1988). For example, various studies have shown that implicit memory tasks are often unaffected by elaborative semantic encoding operations that facilitate performance on explicit tasks (for reviews, see Brown & Mitchell, 1994; Challis & Brodbeck, 1992). Another dissociation between implicit and explicit memory tests has to do with the performance of amnesic patients. Amnesics exhibit severe deficits on explicit tests, yet their performance on implicit tasks is often similar to that of normal subjects (Shimamura, 1986). Hence a dissociation is apparent due to the normal performance on one task and impaired performance on another task.

One of the early views proposed to explain the above dissociations was based on encoding and retrieval processes. Specifically, some authors have concluded that a dissociation between implicit and explicit memory tasks occurs because these two types of tasks involve different modes of processing during retrieval (i.e., activation vs. context-dependent processes) (Graf & Mandler, 1984). Activation mechanisms have been posited to underlie performance on implicit tests, whereas context-dependent processes are thought to underlie recall and recognition (Graf & Mandler, 1984). An activated representation may readily pop to mind on an implicit memory test, but it may contain no contextual information about an item's occurrence as part of a recent episode and therefore does not contribute to explicit remembering of the episode. Therefore, repetition priming requires only the activation of an existing representation in memory during encoding, whereas recall and recognition depend on encoding of more elaborative, contextual information during study. According to this view, if this contextual information is not encoded during the study phase the participants may still perform normally on the implicit test, yet explicit memory performance will suffer.

Subsequently, a multiple memory systems approach has been developed to explain the findings of dissociations. This approach assumes that there are a number of different memory systems that are operating in conjunction with each other (Tulving, 1985). Tulving and Schacter (1990) suggested that results showing a dissociation between explicit and implicit memory performance reflect the use of different memory systems. According to Tulving and Schacter (1990), a Perceptual Representation System (PRS) operates at a presemantic level and this mediates repetition priming on an implicit perceptual test. In an implicit perceptual task such as word stem completion (tur___), participants

concentrate on the perceptual features: Priming is the result of a match between the perceptual details of studied items stored in the PRS and those of the information presented at test. Completion of the stem is assisted free of any conscious recollection of the previous learning episode. In contrast, explicit tasks appear to require a greater level of awareness and increased reliance on elaborative cognitive operations. Explicit tests involve the match between cue information presented at study and information that is stored in episodic memory (Java, 1992). According to Tulving and Schacter (1990), the PRS is not involved in performance on explicit memory tasks.

It has been recognized that the PRS is not involved in performance on all implicit tests (Tulving & Schacter, 1990). For example, an implicit test may provide information that is conceptually related to the studied information, as in the answering of general knowledge questions (e.g., What male fowl is called a tom?) (Blaxton, 1989). The semantic memory system mediates this type of conceptual processing and it is based on the modification or addition of new information to semantic memory at the study phase. At test, the semantic information provided in the question acts as a prime for the answer in memory. It is doubtful that any data-driven analysis of the physical features of the question could aid in producing the desired response. Therefore, on implicit conceptual tasks, much like on explicit tasks, the PRS does not contribute to performance. Rather, this type of task relies on another memory system, such as semantic memory. According to this theory, at least two separate memory systems are involved in priming.

A third theory that has been put forth to explain the dissociations between implicit and explicit tests is based on the concept of processing requirements involved in the various memory tasks. Srinivas and Roediger (1990)

differentiated between implicit tests by suggesting that perceptual tests rely heavily on the match of perceptual features at study and test, whereas conceptual tests require processing of the meaning of words at study for successful performance. Perceptually-based tasks rely on processing the physical features of the presented stimulus in order to perform the tasks. On the other hand, conceptually-based tasks (both implicit and explicit) rely on processing of the semantics of the study items and less upon the processing of the perceptual characteristics. According to this view, performance on an implicit (or explicit) test will benefit if the processing at study matches the processing at test. If a word is processed perceptually at study, then performance will be enhanced on a perceptual test. Similarly, performance on conceptual tests will benefit if the information is processed for meaning. Therefore, when processing information perceptually, performance on the implicit perceptual memory test should be optimal. However, performance on the explicit memory test may suffer due to the lack of conceptual processing.

In summary, three theories have been proposed to account for the dissociations found between performance on implicit and explicit memory tests. Early views tended to focus on encoding and activation (Graf & Mandler, 1984), which were followed by the memory systems view by Tulving and Schacter (1990). The last theory examines the broader area of perceptual and conceptual processing, whether they are implicit or explicit memory tests (Srinivas & Roediger, 1990). Both the memory systems view and the processing view draw distinctions not only between implicit and explicit tests, but also within the implicit memory tests themselves.

Dissociations Among Implicit Tests

McDermott and Roediger (1996) outlined several differences between the above mentioned implicit memory tests. For example, conceptual implicit tests have been found to demonstrate a generation effect (a memory advantage for words generated over words read from a semantic cue) and a levels of processing effect (LOP; a memory advantage for words processed in terms of their meaning over those that are processed at a more shallow level) whereas perceptual implicit tests often show a reverse generation effect (an advantage of reading a word over generating it from a semantic cue) (but see Gardiner,1988) and no LOP effect (see Brown & Mitchell, 1994; Challis & Brodbeck, 1992).

Priming on perceptual tests is greater following reading a word than generating it from a conceptual cue presumably because, in the generate condition, the target word is not visually perceived; therefore, the opportunity for perceptual priming is often reduced or absent. According to the transfer appropriate processing approach, conceptual tests invoke participants' semantic knowledge, and therefore performance on these tasks should be affected by study manipulations that induce meaning-based processing, such as generating a word at study from a conceptual cue. Accordingly, conceptual tests are not affected by a change in the modality between study and test (McDermott & Roediger, 1996). That is, if participants are presented with information visually at study and then tested in the auditory modality, they will still perform normally on a conceptual test.

On the other hand, it is assumed that any changes in the processing of the physical features of an item between study and test should reduce the amount of perceptual priming according to the PRS (Tulving & Schacter, 1990). However, a change in the modality does not always eliminate repetition priming since some amount of residual priming is sometimes found (Light &

LaVoie,1993). Thus, some other memory system must also be involved, possibly one that is conceptual in nature (Light & LaVoie, 1993). Since conceptually-based processing is linked to semantic memory, this nonspecific component of priming on perceptual tests may be related to activation in this system. The total priming effect would therefore be based on two memory systems, the PRS and the semantic memory system. It is apparent that performance on conceptual and perceptual implicit tests is affected by different manipulations, which leads to the above notion of different systems operating for each test. The relative contribution of each system will determine the effect of different independent variables.

One manipulation that has not demonstrated consistent effects on implicit memory tests is levels of processing. A typical levels of processing manipulation involves comparison of a semantic study condition (e.g., rating the pleasantness of a word) versus a physical study condition (e.g., searching for specific letters, such as vowels in a word). Manipulation of levels of processing is thought to promote different amounts of conceptually driven processing at study, whereas perceptual processing of target items is assumed to be similar across the different study conditions, at least when the entire word is read at study (Roediger, 1990).

Until recently, the predominant view has been that LOP effects are not present on perceptually-based implicit memory tests (Graf & Mandler, 1984; Hamann, 1990). It has been hypothesized that a test that relies solely on perceptual processing will be insensitive to any elaborative processing manipulations such as semantic study conditions (Hamann, 1990). In a review by Brown and Mitchell (1994), a significant levels of processing effect was found in over half of the implicit memory studies that were examined. This conclusion

held even when only perceptual implicit memory tests were considered. One interpretation that has been offered to account for these effects is that performance on implicit tests may be contaminated by explicit retrieval, specifically, that participants may attempt to consciously retrieve studied items even though the instructions for the implicit test do not specify this (e.g., Challis & Brodbeck, 1992; Jacoby, 1991). Since performance on explicit memory tests is affected substantially by conceptual processing at study, this explanation could account for the finding of LOP effects on allegedly perceptual implicit tests.

The processing model assumes that most memory tests involve a mixture of perceptual and conceptual processing and that it is possible to distinguish between types of perceptual and conceptual processing (Cabeza, 1995). Cabeza (1995) found a significant main effect of LOP on both the kanji-fragment completion test and general knowledge questions. While the fragment completion test is considered to be primarily a perceptual test and the general knowledge test is considered to be primarily a conceptual test, these data along with the meta-analysis reported by Brown and Mitchell (1994) support the hypothesis that both types of tests may be influenced, to different degrees, by conceptual processing, consistent with the processing model. That is, neither one of the tests is purely perceptual or conceptual; rather, a mix of processing is occurring.

Dissociations between performance on perceptual and conceptual tests of priming have been observed, suggesting that different processes support priming on the two types of tests (Tulving & Schacter, 1990). As discussed previously, conceptual implicit tests are often described as not being affected by a change in modality. Similarly, perceptual tests are often described as not

being affected by LOP. However, one must be cautioned when making conclusions on the LOP findings since Brown and Mitchell (1994) found 76% of perceptual implicit tests were affected by this manipulation. Once again this finding may provide evidence in favor of the processing view, since a purely perceptual test should not demonstrate a LOP effect.

Srinivas and Roediger (1990) say the finding of dissociations between implicit measures of memory (Blaxton, 1989; Witherspoon & Moscovitch, 1989) undermines the argument that dissociations between explicit and implicit measures imply the existence of different memory systems. According to the memory systems view, dissociations between implicit tests would be explicable by arguing that performance on the word fragment completion test is subserved by the PRS and performance on the category association test by the semantic system. If performance on implicit conceptual memory tests and implicit perceptual tests were subserved by a single memory system, it might be expected that no dissociations would occur among implicit tests. The transfer appropriate processing approach (memory performance is a function of the overlap of operations at study and test) may be better able to account for the above-mentioned dissociations by pointing to the different processes underlying each task. This approach postulates that the various implicit tests would rely on different types of processing at study, thereby allowing for different effects of variables on these tests.

Both the memory systems and processing views have attempted to account for the dissociations between implicit perceptual and implicit conceptual tests. These dissociations create difficulties for the memory systems view, since this view has previously stated that implicit and explicit memory are subserved by different systems. In order to accommodate the new data, they must create an

additional memory system or subsystem. The processing view appears to more parsimoniously account for the dissociations between implicit memory tests by focusing on the match between processing at study and test.

Regardless of the type of implicit memory task used, there have been various concerns expressed in regards to the basis of performance on tests of implicit memory. A number of investigators have argued that the use of a conscious strategy can increase the amount of priming on an implicit memory test (Richardson-Klavehn & Bjork, 1988). These researchers suggest that performance on an implicit memory test may be inflated, since the participants may be using explicit retrieval to recall the words from the study phase. This is a major criticism of the work on implicit memory, yet several problems arise with this hypothesis.

If priming sometimes reflects use of conscious retrieval, why would priming effects not be larger for words that are well-remembered on direct tests of memory (i.e., deeply processed and generated items) than for items that are poorly remembered? The fact that several studies have shown differential effects of experimental variables on implicit memory and explicit memory tasks when identical test cues were provided, and only the implicit/explicit nature of test instructions was varied (Graf & Mandler, 1984) suggests participants do not consistently use explicit strategies on implicit memory tasks. If participants did use such strategies, we would expect to see parallel effects of experimental variables when the same cues are provided on implicit and explicit tasks.

There appears to be no direct evidence supporting the explicit contamination hypothesis, yet this hypothesis appears extensively in the literature. One area in which this hypothesis of explicit contamination has been used extensively is implicit memory research with older adults. While older adults have been found

to be consistently impaired on tests of explicit memory, their performance on tests of implicit memory has been less consistent. If an older adult's performance on an implicit memory test relies upon any form of explicit retrieval, the older adults would be expected to show an impairment, when compared to young adults, since older adults demonstrate impaired explicit memory performance. While some studies have shown such impairments, other studies have shown no reliable decrease in priming in older adults. Thus, this hypothesis does not adequately describe all the implicit memory data reported with older adults.

Age Differences

In the past, the majority of memory work done with older adults was based on explicit memory tasks. Older adults' explicit memory performance has consistently been found to be impaired (Craik,1977). To explain age differences in explicit memory, Craik (1977) suggested that the processing of older persons was inefficient rather than truly defective. The idea is that sufficient attentional resources are potentially available to older adults but that for some reason these resources are not always mobilized. Thus, performance is impaired on tasks such as explicit memory tests that require lots of resources. For example, tasks that require self-initiated constructive operations and offer little environmental support for retrieval show sizable age-related differences in memory (Craik, 1986). The self-initiated activities that are required for optimal performance on explicit memory tasks may be described as processes which are voluntary, intentional and effortful (Craik, 1986). As opposed to older adults, young adults do not have difficulty recruiting the resources required to perform these self-initiated activities.

The difference between young and older adults' performance on explicit memory tests can be reduced both by constraining encoding operations by means of semantic orienting tasks at encoding and by giving recognition tests rather than recall tests at retrieval (Craik, 1977). Older adults appear to retain the ability to encode information effectively, but they often fail to carry out these encoding operations unless guided by tasks or instructions. Therefore, when a semantic encoding task is used, the older adults' performance may be more comparable to that of the young adults. Recognition tests require less effort than recall tests and therefore will decrease the demands put on the older adult. These decreased demands lead to smaller deficits in performance. Several studies have demonstrated improved performance by older adults on recognition tests compared to free recall tests (see Craik, 1986). This provides evidence that older adults may not be impaired, or at least may not be impaired equally, on all types of explicit memory tests.

In recent years, the focus of research has turned to implicit memory performance (Chiarello & Hoyer, 1988; Light & Singh, 1987). Some studies of implicit memory with older adults show normal priming relative to that of young adults (Light & Singh, 1987; Java & Gardiner, 1991) while other studies show reduced or zero priming (Chiarello & Hoyer, 1988; Hultsch, Masson, & Small, 1991). Across studies, there has been considerable variation in the type of implicit memory test as well as in conditions of presentation, making it difficult to pinpoint the reasons for the discrepant findings. A summary of these studies is presented in Table 1.

Light and Singh (1987) examined performance on a word identification test and failed to find significant age differences. Both young and older adults were able to correctly identify previously exposed words faster than new words, and

this priming effect was equal for the young and older adults. The failure to find age differences in the word identification task has since been replicated (Hashtroudi, Chrosniak, & Schwartz, 1991; Light, LaVoie, Valencia-Laver, Albertson, Owens, & Mead, 1992). It appears that the majority of the studies failed to find age-related differences on the implicit perceptual test of word identification (but see Abbenhuis, Raaijmakers, & vanWoerden, 1990, for an exception).

A different perceptual implicit test was used by Java (1992), who studied age-related effects on priming in an anagram solution test. No significant age differences were found on the anagram solution tes; however, age differences were apparent in recognition. Once again, no age differences were found on a perceptual implicit test, while the explicit test showed impairments.

Another implicit perceptual test that is used quite often by researchers is the word stem completion test. Light and Singh (1987) found that age did not significantly affect priming on this test, although in each of their experiments, there were small differences favoring the young. On an explicit test, young adults recalled reliably more than the older adults. Light and Singh (1987) also reported an interaction of age and LOP on both the recall and recognition tests, indicating that the younger adults benefited more from semantic encoding than did the older adults. However, the interpretation of these results is compromised by floor and ceiling effects in performance. In free recall, both age groups recalled fewer than 10% of the targets following non-semantic encoding. In recognition, both groups correctly identified more than 90% of the targets following semantic encoding. Thus, it is unclear how the statistical interactions are to be interpreted.

Java and Gardiner (1991) also found that priming on the word stem

completion test showed a small and nonsignificant effect of age, confirming the results of Light and Singh (1987). Such findings indicate that age-related memory impairments are particularly associated with explicit memory and that priming effects in implicit tests may be relatively intact in the elderly.

Contrary to the above research, Chiarello and Hoyer (1988) obtained significant age differences on a word stem completion test. In addition, both young and older adults demonstrated more priming after completing a semantic orienting task. Hultsch et al. (1991) also provided clear evidence of significant age differences on a word stem completion test. Younger adults' stem completion performance was more strongly influenced by previously seen words. The words were initially presented to subjects in the context of a lexical decision task which requires relatively shallow processing to complete, thus making it relatively unlikely that performance on the word stem completion test was contaminated by explicit retrieval processes. In addition, the participant was not led to expect that later recall or recognition of the items would be requested.

Davis, Cohen, Gandy, Colombo, VanDusseldorp, Simolke, and Romano (1990) used a liking orienting task followed by a word stem completion test and found that adults in their 70's and 80's demonstrated significantly lower priming than adults in their 50's and 60's. Davis et al. (1990) also found impaired recall for the older adults. These results suggest an age-related decline in both implicit and explicit memory performance. The results of this study, combined with those of Chiarello and Hoyer (1988) and Hultsch et al. (1991), lead to the conclusion that there are significant age differences in priming on tests of word stem completion. This conclusion is contrary to the evidence presented by Light and Singh (1987), Java and Gardiner (1991), and Java (1992).

The multiple memory systems approach attempts to explain the contradictions in the literature by proposing that different memory systems are being used on each type of test. Java (1992) applies the principles of the multiple memory systems approach to her findings. According to this author, the anagram solution task taps the PRS, whereas recognition utilizes a memory system in which the elderly have been shown to be impaired. Unfortunately, as mentioned previously, not all implicit memory tests demonstrate equivalent performance between young and older adults and therefore, the multiple memory systems view does not readily account for the discrepant findings.

The memory systems themselves may not be impaired; rather age differences in the strategic use of information may be responsible for the inconsistent findings. The older adults may have access to the information but for some reason they are not making use of this information. For example, Chiarello and Hoyer (1988) found that when older adults were presented with a cued recall test, they did not guess the first word that came to mind in order to complete this test. While the cued recall performance of the older adults declined to zero after the delay, their priming remained reliably above chance, suggesting that the older adults had information available from the study trial but that they were not making use of this information on the explicit task. However, this explanation does not account for the discrepancies in the literature.

The environmental support hypothesis has also attempted to account for the discrepant findings by suggesting that tests with more environmental support for the participant are more likely to demonstrate normal performance. Craik (1986) stated that it is possible to hold the amount of environmental support constant while varying the processing requirements of memory tasks. When the

amount of retrieval support is held constant by using the same cues for both explicit and implicit tasks, the magnitude of the age difference continues to be greater on explicit than on implicit measures.

Light and Singh (1987) held the amount of retrieval support constant by comparing performance on word stem completion and cued recall using the same three letter stems as cues for both tasks. These researchers found reliable age differences for cued recall but not for word stem completion, which suggests that the critical variable is not strictly the amount of retrieval support but also intention to remember at test. These findings do not necessarily deny the importance of retrieval support. Nevertheless, retrieval support is not able to account for all of the effects (Light & LaVoie, 1993).

To recap, the memory systems view attempts to explain the discrepant findings with regards to age differences on implicit memory tests by pointing to a memory system that is impaired for explicit tests and another system which functions normally for implicit tests (Java, 1992). However, this does not explain all of the findings, nor does the hypothesis which describes the way in which the strategic use of information is used by adults. The retrieval support theory also fails to account for all of the inconsistent findings in this research area.

To clarify the results of past research, Light and LaVoie (1993) conducted a meta-analysis of age differences on a number of implicit tests including word stem completion. The majority of the studies that they evaluated were based on the traditional perceptually-based implicit memory tasks described above. Their analysis revealed a small, but reliable, age difference in implicit memory performance. One implication of this result is that the failure by some researchers to find a reliable age effect on priming may be due to the relatively small magnitude of such effects (cf. Light et al., 1992).

The observed age differences, small as they were, favored the young subjects, raising the possibility that there are small but real population differences that some experiments lack sufficient power to detect (Hultsch et al., 1991; Light & Singh, 1987). Hultsch et al. (1991) proposed that in order to consistently find significant age differences on implicit tests such as word stem completion, designs with substantial power are required. According to these researchers, Light and Singh (1987) may indeed have found age differences if the statistical power of their experiment was stronger. Nonetheless, some studies show significant age differences without a large number of participants (Chiarello & Hoyer,1988). Even though a small number of participants were used in these studies, the level of statistical power was sufficient to detect an age difference.

Discrepancies in findings on implicit memory tests have also been attributed to explicit contamination. The study reported by Chiarello and Hoyer (1988) has the possible problem of explicit contamination since the participants were given three successive completion tests. They may have realized that some of the stems were completed with presented words and consciously attempted to recall those words on later completion tests. Also, because word stem completion was constrained by word length, the completion task may have induced some reliance on explicit memory. Since word length was constrained, participants may have consciously searched for words that fit the specific criterion, instead of answering with the first word that came to mind.

Light and LaVoie (1993) found a moderate level of priming, yet they concluded that implicit memory performance may be affected by conscious retrieval strategies, since priming tasks are subject to contamination by deliberate recollection (cf. Jacoby, 1991). Young adults consistently perform

better than older adults on tasks requiring deliberate recollection. Consequently they may be more likely to notice that they are producing previously seen list members while performing priming tasks, and as a result may switch to intentional retrieval. Young participants may be more likely than older adults to use explicit memory as a means of enhancing implicit test performance, thereby yielding age differences in implicit memory performance.

Various methods have been derived to test the explicit contamination hypothesis, one of which involves the testing of amnesic patients. Amnesic patients show substantial deficits in explicit memory, yet they often demonstrate preserved priming on implicit memory tests (Shimamura & Squire, 1984). If these patients were to rely on their explicit memory, they would not demonstrate normal priming on the implicit test. Therefore, the performance of amnesic patients provides evidence against the conscious recollection hypothesis. Since the explicit contamination hypothesis is not fully supported, it does not provide a clear resolution of the inconsistencies in the literature in regards to performance on implicit perceptual tests.

In addition to the discrepant findings of age differences on implicit perceptual tests, a number of studies have also uncovered inconsistencies in regards to the LOP effect in older adults. Examining the LOP effect allows one to obtain further insight into the possible reasons for the discrepancies in the literature involving age differences on implicit tests. The explicit contamination hypothesis may be examined in the context of LOP data. When deeper levels of processing are used in the study condition, it may create a situation where explicit retrieval strategies are more likely to be used. Since older adults generally will not make use of such strategies unless induced to do so, they will not benefit from the deeper level of processing. Young adults on the other

hand, may take advantage of this explicit information and therefore, demonstrate a significant LOP effect on implicit tests.

Light and Singh (1987) examined LOP effects in implicit perceptual tests with young and older adults. They found that older adults showed a levels of processing effect on the implicit memory test, as well as a significant age by encoding task interaction. The young adults benefited more than the older adults from the semantic orienting task. This interaction lends support to the claims that older adults may not use efficient strategies in order to benefit from the deeper levels of processing. The levels of processing effect was also present on the explicit task, even though the two age groups were not equivalent in their performance on the explicit test. Java and Gardiner (1991) also examined levels of processing effects on a word stem completion task. Contrary to Light and Singh (1987), no LOP effect was obtained for older adults on the word stem completion test, yet the young adults demonstrated a significant LOP effect. Poisson (1996, unpublished) also found that older adults failed to demonstrate a significant LOP effect on word stem completion and general knowledge questions. Yet one must be careful when interpreting the findings of Poisson (1996), since, unexpectedly, older adults failed to demonstrate any priming on the implicit tests.

Consistent with Light and Singh (1987), Chiarello and Hoyer (1988) also found that implicit memory performance for older adults on a word stem completion test was better following a pleasantness rating than a vowel counting task. It is possible that the type of word stem completion task used by Chiarello and Hoyer (1988) may have contributed to the significant LOP effect. Unlike previous studies that used the first three letters of a word followed by a blank line, Chiarello and Hoyer (1988) used a word stem completion test that

constrained the word length, indicating the required number of letters with a specific number of dashes for each word. This may have led the participants to treat this much like a cued recall test in which they are given a three letter word stem and told to complete the stem with a word that they have just studied. If this was the case, based on previous literature, a LOP effect would be expected (see Brown & Mitchell, 1994). Nonetheless, this is not to say that it is not possible to obtain a LOP effect on word stem completion, as has been demonstrated in the meta-analysis by Brown and Mitchell (1994). Much like age differences on implicit memory tests, the literature examining LOP effects has also failed to provide consistent findings.

In summary, implicit perceptual tests such as word stem completion have demonstrated inconsistent results in the literature. Light and Singh (1987) and Java and Gardiner (1991) failed to find significant age differences on word stem completion, while Chiarello and Hoyer (1988) and Hultsch et al. (1991) do indeed find significant age differences. Proposed explanations for the discrepancies in the literature have been small sample size leading to relatively low statistical power and the explicit contamination of implicit memory tests by explicit retrieval. However, neither of these hypotheses provides a clear explanation of all the evidence. Perceptual implicit tests also have not shown consistent effects of other manipulations such as LOP. Once again the researchers have provided evidence of LOP effects in one study (Light & Singh, 1987) and a lack of effects in another study (Java & Gardiner, 1991).

Conceptual implicit memory tests also yield an inconsistent pattern of performance. Rose, Yesavage, Hill, and Bower (1986) used the spelling of biased homophones to examine age differences in conceptual priming. Younger adults showed a greater tendency to use the less frequent spelling of

the homophone when that item was presented at study. In contrast, no priming was observed in the older adults. Davis et al. (1990) replicated these results. Howard (1988), on the other hand, reported small but unreliable age-related differences in performance on the homophone spelling test.

Light and Albertson (1989) used a category exemplar generation task, which is a conceptually-based test of implicit memory (Hamann, 1990), and found small and unreliable age differences between young and older adults. The older adults were significantly impaired on the explicit memory test. Using a similar experimental procedure, Isingrini, Vazou, and Leroy (1995) replicated the findings of no age differences on a category exemplar generation task. Contrary to these findings, Grober, Gitlin, Bang, and Buschke (1992) found decreased priming for older adults using a category association test. These divergent results may be attributable to any of several procedural differences across studies.

The way in which priming was measured varied between studies. Grober et al. (1992) only counted the first word produced by participants, whereas Light and Albertson (1989) counted the number of targets that appeared in the first eight category members that were produced. The order of presentation of the memory tests also differed between studies. Grober et al. (1992) administered the implicit test after the participants had responded to the explicit task. Light and Albertson (1989) varied the order of presentation of the memory tests. The procedure used by Grober et al. (1992) may have introduced contamination by explicit retrieval strategies, which was differentially beneficial for young adults. As a result of the enhanced explicit memory performance, the younger adults would have experienced increased practice at recalling the words, which again provides an additional benefit. Finally, it is also possible that the decline in

conceptual priming may not occur until late adulthood: Grober et al. (1992) tested participants who had a mean age of 78, whereas Light and Albertson's (1989) participants had a mean age of 69. In contrast to this interpretation, Isingrini et al. (1995) tested participants who had a mean age of 81 and found no age differences.

It appears that aging is sometimes associated with reduced priming on conceptual implicit tasks. Two investigations with the biased homophones test (Davis et al., 1990; Rose et al., 1986) found age differences and two studies with the category exemplar generation test (Isingrini et al., 1995; Light & Albertson, 1989) showed that the performance of older adults was comparable to that of the young adults on conceptual priming tasks. Grober et al. (1992) found that older adults showed less priming in a category association test than younger adults. Again the argument could be that these conceptual tasks are susceptible to explicit contamination. However, amnesics also show normal performance on category production tests (Graf, Shimamura, & Squire, 1985), which makes it unlikely that these tests are vulnerable to contamination since amnesics exhibit severe deficits in explicit memory performance.

Since implicit perceptual and conceptual tests both demonstrate inconsistencies when examined individually, it would be interesting to compare performance on these tests. Small et al. (1995) focused on the distinction between perceptually- and conceptually-based tests. They used the conceptual test of general knowledge questions and the perceptual test of word stem completion. Small et al. (1995) found no reliable age differences on the general knowledge questions, but found substantial age differences on the word stem completion test. The finding of age differences on word stem completion is consistent with previous work (Chiarello & Hoyer, 1988; Hultsch et

al., 1991). Previous explanations for the findings of age differences, such as explicit contamination, seem unlikely given the pattern of age differences. For example, in Small et al. (1995), there were no differences in priming between the middle age and older group, yet there were evident differences in explicit memory performance. Therefore, differences in explicit memory performance may not be perfect predictors of contamination on implicit memory tasks. Middle age adults may not show explicit contamination, whereas young adults may, even though both groups have better explicit retrieval than older adults. Thus it is not solely the difference in the opportunity for contamination based on explicit retrieval ability. The strategic use of this opportunity may also be important.

Small et al. (1995) presented the study list in the context of a lexical decision task which requires relatively shallow processing to complete, thus making it relatively unlikely that performance on a subsequent implicit memory test would be contaminated by explicit retrieval strategies. In addition, the participant was not led to expect that later recall of the items would be requested. Therefore, the significant effect of age on the word stem completion test is not likely due to explicit retrieval. Small et al. (1995) also address the issue of statistical power. Their sample size was extremely large. As a result, power for this experiment was 0.77 compared to power for Light and Albertson (1989) of 0.25. Even with the substantial differences in power, both studies failed to detect age differences on conceptual implicit tests. Therefore, any lack of age differences on the general knowledge questions can not be attributed to small sample size.

Although there was no evidence of age differences on the conceptual implicit test, the overall level of priming was substantially smaller on the general knowledge test compared to the word stem completion test. Even though smaller in magnitude, the size of the priming effects on the general knowledge

test was consistent with previous findings (Blaxton, 1989). Blaxton (1989) found that making the study task more semantic resulted in a nonsignificant increase in priming on general knowledge questions. Small et al. (1995) did not manipulate the nature of the encoding task but proposed that if a more semantic orienting task were used, compared to the lexical decision task, the pattern of age differences might change. In particular, no age differences would be found on the general knowledge test, and performance for each age group would be enhanced.

Small et al. (1995) predicted that performance on the conceptually-driven tests of general knowledge questions and fact recall should correlate significantly, but failed to find these results. But again, had deeper, more elaborative study processing been used, a different pattern of effects might have been observed. A logical next step is to determine whether older adults will show enhanced priming effects on a conceptual implicit test when a more semantic orienting task is used.

Poisson (1996, unpublished) conducted a pilot study in order to determine whether a more semantic orienting task would indeed increase the amount of priming displayed by the older adults. Older adults failed to demonstrate significant priming on either the word stem completion task or the general knowledge questions in Poisson's (1996) study. In fact, older adults in the semantic study condition on the general knowledge test actually demonstrated priming that was in a negative direction. These results are contrary to those reported by Small et al. (1995), who found significant priming on general knowledge questions for older adults. The results of Small et al. (1995) appear to imply that the use of a more semantic orienting task would result in a levels of processing effect. Small et al. (1995) were the first to compare performance on

a perceptual and conceptual implicit test with young, middle age, and older adults and further work is needed to verify their findings.

The purpose of the present study was to replicate and extend the study conducted by Small et al. (1995) in an attempt to determine if young, middle age, and older adults display normal priming on two types of implicit memory tasks: word stem completion and general knowledge. The nature of the encoding task was manipulated. In the vowel counting condition, participants were required to count the number of vowels in each word. In the second condition, designed to induce more elaborative processing, participants rated the pleasantness of each word on a 7 point scale. An even more semantic task of generating an associate was the third orienting task and finally, a lexical decision task was used in order to compare the results directly with those of Small et al. (1995). Participants completed a word stem completion test, a general knowledge test, and two explicit measures, word and fact recall. The word recall test used cued recall, with the three-letter stems serving as cues. Following Small et al. (1995), the cued word recall test was based on categorized words. The fact recall test used the same types of questions as the general knowledge test, however the instructions were varied to obtain a measure of explicit memory performance. It is important to note that a number of the design features in the present experiment were selected to replicate procedures reported by Small et al. (1995).

Testing took place over two sessions in order to minimize concerns with contamination. If both of the implicit memory tests were given in the same session, there was a greater risk that some of the participants, especially the young, would become aware of the nature of the tests. Participants may make use of this information by using explicit retrieval strategies to enhance implicit

test performance.

It was hypothesized that all age groups would show significant priming on the conceptual implicit task of general knowledge. It was also predicted that no age differences would appear on this test. This hypothesis is consistent with Craik's (1977) notion that implicit memory tests require less effort than explicit tests, and with the findings of Small et al. (1995). However, age differences may appear, since there would appear to be more opportunity for explicit contamination with the conceptual test. Younger adults would be expected to benefit more than the middle age and older adults because their explicit retrieval ability is greater and because they are more likely to adopt an explicit retrieval strategy.

Any age differences that have been found on word stem completion tests were small and sometimes unreliable, therefore leading to the prediction that significant age differences may not be found in the present study on the word stem completion test. Very little data exist for the middle age group. However, it is predicted that this age group will also demonstrate significant priming on word stem completion (Davis et al., 1990). This hypothesis is based on the notion that the PRS is responsible for priming on perceptual implicit tests and it appears that this system is intact in older adults and therefore, middle aged adults as well (Mitchell, 1989). It may be noted, however, that this prediction conflicts with the findings of Hultsch et al. (1991) and Chiarello and Hoyer (1988), since both studies found age differences on word stem completion tests. Both the memory systems approach and the transfer appropriate processing approach predict significant priming on the word stem completion test. In order for a word printed in isolation to be processed conceptually, the perceptual features of the word must first be processed. Therefore, if conceptual priming is

displayed, some form of perceptual priming should also be demonstrated.

A second purpose of conducting this experiment was to determine the effects of levels of processing on the various implicit tests. Based on both the transfer appropriate processing approach and the memory systems approach, it was hypothesized that all age groups would show a levels of processing effect and that this would be most evident on the conceptual test. If the material was studied for meaning, performance on a subsequent test of meaning would be enhanced. The implicit perceptual test was also expected to show a LOP effect, based on the meta-analysis conducted by Brown and Mitchell (1994).

Based on previous research, it was expected that recall performance would be impaired in older adults (Craik, 1986) compared with middle age and young adults. The majority of work with older adults using explicit memory tests has found impairments on recall and recognition. The older adults were expected to show less impairment on the cued recall task than on the fact recall test, since more retrieval support was provided on the cued recall test. That is, the cued recall task provided the older adults with the first three letters of the word to be recalled and thereby increased the amount of environmental support available for retrieval. Fact recall, on the other hand, provided less retrieval support for the older adults. Consistent with most previous work, all age groups were expected to demonstrate a LOP effect on the explicit tests (Craik, 1986).

Small et al. (1995) proposed that had deeper, more elaborative processing occurred at study, then the two conceptually based tests, general knowledge and fact recall, would have been significantly correlated. If these two tests were correlated it would imply that the same type of conceptual processing underlies performance on both tests. Therefore, the present study also examined the correlations among all test measures in an attempt to evaluate the various

theoretical explanations.

Method

Participants

The sample consisted of 128 healthy, community-dwelling adults residing in a small Northern Ontario community, and 64 students attending Wilfrid Laurier University. The middle age and older adults were volunteers from the community who had expressed an interest in participating in psychological research. The young adults participated for course credit in the Introductory psychology class at Wilfrid Laurier University. The age, gender, vocabulary and educational characteristics of the sample are summarized in Table 2. All of the older adults completed a cognitive test to insure that no memory impairments were present. None of the participants reported suffering a previous head injury resulting in temporary unconsciousness, nor were any currently taking any medication that might interfere with their cognitive performance.

Design

The between subject factors were age (young, middle, old) and order of test blocks (session order A, session order B). The within subject variables were the orienting task (generate associate, pleasantness, vowel, lexical decision), the type of implicit test (word stem completion, general knowledge) and the type of explicit test (cued word recall, fact recall). Session order A consisted of a study trial, a distractor task, the general knowledge test, a second study trial and the cued word recall test. Session order B consisted of a study trial, a distractor task, the word stem completion test, a second study trial and a fact recall test. Participants were randomly assigned to the order of tasks.

Materials

A scale that measures cognitive mental status (Mini-Mental State Exam

(MMSE) - includes eleven questions that focus on the cognitive aspects of mental functions) was administered to the older adults. The vocabulary subscale of the Weschler Adult Intelligence Scale Revised was also administered to measure the verbal abilities of the participants, which is a standard technique reported in the literature.

Different sets of words were selected for each of the tests. Two sets of 20 words each were used for word stem completion. These items were selected according to two criteria. First, the three-letter stems for these items not only had to be unique within the set of 40 stems appearing on the word stem completion test, but in addition they had to be unique among all items (words and non-words) used for the other tasks. Second, they had a probability of completion of .13 to .20 in a set of stem completion norms (Horton 1995, unpublished). In each case, participants studied one of the two lists. The test list for both implicit memory tests consisted of all 40 words. Half of the words in each list were studied targets and the other half were non-studied baseline items, and this was counterbalanced across age and encoding condition. The items for all tasks appear in Appendix A.

For the word stem completion test, the first three letters from each of the 40 words from both study lists were printed in lower case letters followed by a 2 cm line (e.g., tur___). All of the word stems were presented in random order in a 14 point font on a 4 x 6 in. (10.1 x 15.2 cm) index card.

For the general knowledge test, two sets of 20 words each from Small et al. (1995) were used. Participants were presented with 40 relatively difficult general knowledge questions (e.g., What male fowl is called a tom?) that required one-word answers. There were 2 practice questions at the beginning of the booklet. There was a blank line printed below the question for the

participants to write a response. Half of the questions could be completed with a word presented earlier in the study trial.

Two sets of 20 words each were selected for the cued recall test. Each list was composed of 4 words from each of 5 taxonomic categories. High-frequency exemplars were chosen from the Battig and Montague (1969) norms. There was no overlap between categories and exemplars among the two lists. The two lists were counterbalanced across participants. Individual words from each of the two lists were presented in random order on index cards. The study trial was followed immediately by a 4 minute written cued recall test in which the first three letters of all 20 items were presented. The participants were instructed to complete the word stems with the words from the study trial. Those participants who were asked to complete a lexical decision task were instructed to recall only the real words that they were exposed to in the study phase.

Fact recall was examined by presenting participants with two lists, each consisting of 20 general knowledge questions (e.g., What is the last name of the author of the book "1984"?) which were selected from those developed by Nelson and Narens (1980). The two lists of questions were sorted to roughly equate the sets in terms of content and difficulty. Once again, participants in the lexical decision task condition were asked to recall only the real words that they had just studied. The questions were presented on pages and the participants were asked to write their answer on a blank line below the question. Participants were given 5 minutes to complete the questions.

There was also an additional 20 nonwords that were used for lexical decision. Two practice words were presented at the beginning of each study list. Each word was typed in a 14 point font on a 4 x 6 in. (10.1 x 15.2 cm) index card.

One distractor task consisted of a single page with 60 first names and a blank line beside each name. The first names were completed to make the name of a famous person. For a second distractor task, participants were asked to generate the names of the states of the United States of America.

Procedure

Young adults were tested individually in a room at Wilfrid Laurier University at a time that was convenient. In the case of the middle aged and older participants, testing took place in their homes. The participants completed two experimental sessions, separated by a period of 48 hours. At the beginning of the first session, an informed consent was given to the participants and their rights were identified. Basic demographic information was then collected, followed by completion of the MMSE and the WAIS-R vocabulary subscale. In the vocabulary test, participants were presented with a word and they were to provide a definition of the word.

For test order A, session 1 included the general knowledge test followed by cued word recall, and session 2 involved the word stem completion test followed by fact recall. For test order B, the tasks were switched across sessions. The order of the tests was always the same within a session (i.e., the implicit test was always before the explicit test). Half of the participants in each age group received each order of testing. Each participant completed all of the four orienting tasks, such that a different orienting task was paired with each of the tests.

For the study trial, the participants were given a group of 23 index cards with instructions to either complete a lexical decision task, generate associate, rate the words for pleasantness, or count the number of vowels in each word. For those given the lexical decision task, the participants received a list of 44 letter

strings, which included two nonwords and two words as primacy buffers. Participants were instructed to state whether the letter string presented was a real word or not. Participants in the generate associate condition were asked to look at the word on the index card and to think of a word that they would associate with the presented word. Participants in the pleasantness rating condition were asked to look at each word carefully as it was presented, to think about the word's meaning, and to decide how pleasant or unpleasant they found the meaning of the word. Participants were presented with a 7-point scale (1 - very unpleasant, 7 - very pleasant) with which to rate their judgments. Participants in the vowel counting condition were asked to count the number of vowels in each word. For a complete description of the instructions, please see Appendix B.

Participants in all conditions were required to give a verbal response and the experimenter recorded the answers. All of the study tasks were self-paced, but with a maximum of three minutes allowed for the entire study session. All of the participants completed the study session within the allotted time period, with very little difference in the amount of time required to complete the study session.

In the first session of the experiment after the MMSE and the WAIS-R vocabulary subtest were completed, the participants were then exposed to one of the above orienting tasks in the study phase. After the study trial, the participants were presented a list of names to be completed in order to make a famous name. This distractor task lasted approximately 5 minutes. For the first test phase of one session, participants completed the general knowledge questions. Participants were asked to write a one-word answer to each question. They were encouraged to make a guess if they were unsure or did

not know the answer. After the general knowledge test the participants were exposed to another study trial. Finally the cued word recall test was given and participants were given 4 minutes to recall as many words as possible.

The other session once again commenced with the previously described study trial. A second distractor task was administered, asking for the States of the Union, which lasted 5 minutes. In the test phase of the experiment, the word stem completion test was administered and participants were instructed to complete the word stems with the first word that came to mind. Another study trial was given, the participants were then presented with a fact recall test and were told to write the answers to the facts that were presented. It is important to note that all of the memory tests were self-paced, with the exception of the cued word recall test. See Appendix C for a copy of the materials used.

At the end of the second session, the participants were fully informed as to the nature of the study and how their participation contributed to the research. Each experimental session lasted approximately 30 to 40 minutes. A formal debriefing sheet was given to the participants and any questions were answered.

Results

For each participant, the items seen during the study trial were classified as target items. The items that were not seen were classified as baseline items. Participants' priming scores were computed as the difference between the number of target items they gave as responses and the average number of baseline items provided by participants who did not study those items.

Since the test instructions advised the participants not to worry about spelling errors, no strict spelling criterion was used. On the general knowledge test, a

response was judged to be correct if fewer than three letters of the answer were placed in the incorrect order. This criterion was used since a number of the answers were unusual words. The same procedure was used for the fact completion test. On the word stem completion test, a response was judged to be correct if the completion of the 3-letter word stem was spelled with a maximum of two letters arranged in an incorrect order. On the cued recall test, the word stems had to be completed with the studied words; for example, if for the stem ros___, the answer was rose, roses was not considered a correct response.

The data were analyzed with a number of two-way ANOVAs using education as a covariate. The data were analyzed according to test type; therefore, the results section will be divided according to type of test. All of the analyses were conducted using an alpha level of 0.05.

A separate analysis of the number of years of education revealed a significant effect of age, $F(2,189)=19.21$, $MS_e=6.43$. However, one must be cautious in interpreting this effect since there was a very small standard deviation for the young adults relative to that for the other two age groups (see Table 2). Due to the magnitude of the differences in education level, this factor was included in all of the analyses as a covariate.

For each test type, separate two-way ANOVAs were performed on baseline scores and priming scores, with age and orienting task as the independent variables and education as a covariate. Following this, a post hoc analysis using Fisher's LSD was conducted to isolate the significant differences. An overall analysis of priming scores was conducted in order to determine if each age group demonstrated priming that was significantly greater than zero. This

analysis was deemed necessary in order to detect any significant priming that may not be evident once the power of the tests was reduced: When the data were analyzed according to encoding condition, the sample size of each group was reduced, therefore creating a reduction of power. Unlike the present study, Small et al. (1995) did not manipulate encoding conditions, and therefore in their case an overall analysis of the data was sufficient.

To further analyze the data, separate analyses were then conducted to determine whether significant priming was evident for each encoding condition within each age group. The two implicit memory tests will be reported, followed by the explicit memory tests, ending with a brief section on the correlational analysis.

Word Stem Completion

The analysis of baseline rates revealed a significant effect of age, $F(2,189)=3.45$, $MS_e=2.61$. Post hoc tests (LSD=0.56) indicated that the younger adults completed more of the stems with baseline items than did the older adults. There were no other reliable differences.

The covariate of education level had a significant effect on priming, $F(1,188)=5.38$, $MS_e=5.62$. Priming scores on the word stem completion test revealed a significant effect of age, $F(2,188)=3.68$, $MS_e=5.62$ (see Table 3.). A Fisher's LSD test (LSD=.82) indicated that the young adults showed significantly greater priming than both the middle age and the older adults, but there were no significant differences between the middle age and older adults. These results replicate the findings of Small et al. (1995) and Poisson (1996) with young and older adults.

However, there was no significant effect of orienting task, $F(3,180)=1.21$, $MS_e=5.86$, nor was there a significant interaction between age and orienting task, $F(6,180)=.29$. The way in which the words were studied did not affect priming on word stem completion for any age group.

Further analyses were conducted to determine whether each age group demonstrated significant priming on the word stem completion test. As hypothesized, all of the age groups demonstrated significant priming, all t s(63)>8.35. As predicted, all age groups demonstrated significant priming following each of the orienting tasks, all t s(15)>3.2, when the data were analyzed according to encoding condition and age group.

General Knowledge

The analysis of baseline rates revealed no significant effect of age, $F(2,189)=1.32$, $MS_e=6.88$. All of the age groups completed a similar number of questions with non-studied words.

The covariate of education level had a significant effect on performance, $F(1,188)=31.55$, $MS_e=10.39$. Contrary to Small et al. (1995), there was a significant effect of age on priming scores for the general knowledge test, $F(2,188)=3.68$, $MS_e=10.39$. A Fisher's LSD test (LSD=1.12) revealed significant differences in priming between young and both the middle age and older adults, but no significant differences between the middle age and older adults.

There was also a significant effect of orienting task, $F(3,180)=4.01$, $MS_e=11.58$. A Fisher's LSD test (LSD=1.36) revealed that participants in the vowel counting condition demonstrated, unexpectedly, greater priming than those in both the generate associate and pleasantness conditions (see Table

4). None of the other pairwise comparisons were reliable.

There was no significant interaction between age and orienting task, $F(6,180)=.83$. Therefore, the way in which the orienting tasks affected performance did not differ according to the age of the participants.

All age groups demonstrated significant priming, all ts(63)>2.06. Young adults demonstrated significant priming following the generate associate, vowel counting and lexical decision conditions, all ts(15)>2.71, but not following the pleasantness condition, t (15)=2.00. Middle age adults failed to demonstrate significant priming following any of the orienting tasks, all ts(15)<1.60. A significant amount of priming was displayed by older adults following the vowel counting condition, t(15)=2.92. However, all of the other conditions failed to show significant priming, all ts(15)<1.95.

Cued Word Recall

As with the previous tests, the covariate of education level had a significant effect on performance, $F(1,188)=17.64$, $MS_e=11.49$. As expected, there was a significant effect of age on cued recall, $F(2,188)=14.53$, $MS_e=11.49$. Once again a Fisher's test (LSD=1.23) revealed that the younger adults performed significantly better than both the middle age and older adults, who did not differ significantly from one another.

As hypothesized, there was a significant effect of orienting task, $F(3,180)=17.04$, $MS_e=9.96$. A Fisher's test (LSD=1.26) demonstrated no significant differences between pleasantness and vowel counting conditions, yet all of the other pairwise comparisons were significant. Those who rated the words for pleasantness and counted the vowels recalled more words than those in all other conditions. Based on previous research, the more semantic task of

pleasantness rating was expected to produce a greater level of recall than the vowel counting task (Craik, 1986).

As with the previous tests, there was no significant interaction between age and orienting task on cued recall, $F(6,180)=1.03$. The pattern of the effects for the orienting tasks did not change across age groups.

All age groups demonstrated cued recall performance that was significantly above zero, all $ts(63)>25.71$. Separate analyses indicated that cued recall was above zero for each encoding condition within each age group, all $ts(15)>8.64$ (see Table 5).

Fact Recall

Once again, the covariate of education level had a significant effect on performance, $F(1,188)=26.82$, $MS_e=13.78$. Unexpectedly, no significant effects of age were found on fact recall, $F(2,188)=1.23$, $MS_e=13.78$. This lack of a significant age effect on fact recall is contrary to Small et al. (1995).

There was a significant effect of orienting task, $F(3,180)=10.56$, $MS_e=13.67$. A Fisher's LSD (LSD=1.48) revealed that all pairwise comparisons were reliable , except between generate associate and lexical decision and between vowel counting and lexical decision. Those who studied the words in the generate condition recalled more than those in all other conditions, except for those who performed a lexical decision task. As expected, the most semantic orienting task provided an optimum level of performance by all age groups. As noted by Craik (1986), when a more semantic orienting task was used in combination with an explicit test that provided the participants with cues for recall, the age differences were minimized. The majority of explicit tests examined by Craik (1986) involved recalling a list of words rather than

answering questions that may rely in part on semantic memory. Therefore, the fact recall test may demonstrate a different pattern of results than the typical explicit memory tests used with adults in general.

Once again, there was no significant interaction between age and orienting task on fact recall, $F(6,180)=.83$.

On the fact recall test, all age groups demonstrated recall performance that was significantly above zero, all $ts(63)>22.93$. Separate analyses were conducted to determine whether a significant amount of recall was evident for each encoding condition within each age group. As expected, all age groups demonstrated a significant amount of recall following each of the orienting tasks, all $ts(15)>9.58$ (see Table 6).

Correlational Analysis

A detailed correlational analysis was conducted for each age group, with the effects of vocabulary being partialled out. The results appear in Tables 7, 8, and 9. Priming on the two implicit tests of word stem completion and general knowledge was positively correlated for older adults, and negatively correlated for the young adults. The middle age adults failed to demonstrate any significant correlations between the implicit tests. Contrary to Small et al. (1995), fact recall was correlated with performance on the general knowledge test for both the older and middle age adults. Once the effect of vocabulary was partialled out, education was not significantly correlated with any test measure for any age group.

Discussion

In order to facilitate interpretation of the results of this experiment, the

discussion is organized according to test type. The two implicit memory tests, word stem completion and general knowledge, are discussed, followed by the explicit tests of cued word recall and fact recall. Within each test type, the issues of age differences are first addressed, followed by whether significant priming was evidenced, concluding with the findings in regards to the levels of processing effect. The results of the present study are examined in the context of previous literature, and any similarities or differences are discussed. As previously mentioned, there has been a great deal of controversy in the literature regarding age differences, specifically on the implicit perceptual test of word stem completion. Subsequently, the various explanations for these discrepancies are examined in an attempt to determine whether the present results provide support for one or more of the proposed theories.

Word Stem Completion

In the past, the implicit perceptual test of word stem completion has demonstrated inconsistent patterns of age differences. For example, Light and Singh (1987) and Java and Gardiner (1991) failed to find significant age differences between young and older adults on word stem completion. Yet, significant age differences were found by Chiarello and Hoyer (1988) and Davis et al. (1990). Hultsch et al. (1991) and Small et al. (1995) also found significant age differences on word stem completion when examining young, middle age and older adults. However, when age differences have been found, they have often been small and sometimes unreliable. Therefore it was predicted that significant age differences would not be found on the word stem completion test. It was also predicted that adults in all age groups would demonstrate a significant amount of priming.

Contrary to the hypothesis, the results revealed significant age differences on

the implicit perceptual test of word stem completion. This finding is consistent with the results of Chiarello and Hoyer (1988), Davis et al. (1990), Hultsch et al. (1991), and Small et al. (1995), who all showed significant differences in priming between young and older adults on a word stem completion test. However, the results of this study are inconsistent with the results of Java and Gardiner (1991) and Light and Singh (1987) who failed to find significant age differences for older adults. Nonetheless, both of these studies found that young adults demonstrated a greater amount of priming, just not at a significant level.

The pattern of age differences was somewhat inconsistent with that found by Davis et al. (1990). In the present study, no significant age differences were found between the middle age and older adults. However, Davis et al. (1990) found significantly lower priming scores for adults in their 70's and 80's than for adults in other age groups. Contrary to the present results, these researchers did not find significant age differences between their middle age adults and the young adults. It is possible that the age of our middle age and older adults may have been responsible for the inconsistent pattern of age differences. Davis et al. (1990) compared adults in their 20's, 30's, 40's, 50's, 60's, 70's and 80's. Therefore, they did not compare according to specific age groups, such as young, middle age and older adults. In the present study it is possible that the participants in their 40's may have performed equivalently to the younger adults if their data had been examined seperately and not combined with other adults in their early 60's. The finding of equivalent performance between middle age and older adults supported findings by Hultsch et al. (1991) and Small et al. (1995).

As hypothesized, all of the age groups revealed a significant amount of

priming on the word stem completion test. This finding is consistent with previous results (Davis et al., 1990; Light & Singh, 1987). Poisson (1996) found significant priming by young adults on word stem completion, but failed to find significant priming from the older adults. The significant level of priming demonstrated by the older adults on the word stem completion test indicated that they are capable of demonstrating priming. It is apparent that the aging process does not prevent the older adults from completing word stems with studied items, yet they do not perform equivalently to the young on this task.

Whether implicit perceptual tests demonstrate a levels of processing effect is another issue that has created controversy in the literature (see Brown & Mitchell, 1994). Light and Singh (1987) and Poisson (1996) both failed to find a levels of processing effect on word stem completion. However, Chiarello and Hoyer (1988) found that priming on word stem completion was significantly better after pleasantness ratings than after a vowel encoding task. It was hypothesized that a significant levels of processing effect would be found on word stem completion.

The hypothesis of a levels of processing effect on the word stem completion test was not confirmed. The failure to find a levels of processing effect was consistent with the results of Light and Singh (1987), and Poisson (1996), but inconsistent with the results of Chiarello and Hoyer (1988). In the present study the priming scores were not affected by the orienting task; pleasantness ratings did not produce a significantly greater amount of priming than did the vowel counting. The lack of a significant interaction between age and orienting task suggests that all age groups were affected similarly by each orienting task. Therefore, it does not appear that the aging process has an effect on the way in which the material is studied. That is, the deeper level of processing on the

word stem completion test did not make a difference for any age group. However, encoding effects may be specific to a particular type of test, like word stem completion. It was not until recently that the possibility of finding a levels of processing effect on an implicit perceptual test was brought forward. Therefore, many researchers would not be surprised that a levels of processing effect was not observed on the word stem completion test. However, contrary to previous beliefs, Brown and Mitchell (1994) concluded that the majority of studies that examined levels of processing effects on implicit perceptual tests do indeed demonstrate significant effects.

To summarize, the implicit perceptual test of word stem completion demonstrated significant age effects, supporting previous findings (Chiarello & Hoyer, 1988; Hultsch et al., 1991; Small et al., 1995). No levels of processing effect was found even though significant priming was evident for each of the orienting tasks. This failure to observe a levels of processing effect is also consistent with previous work (Light & Singh, 1987). However, it is interesting to note that previous studies that have found significant age differences have also found a significant levels of processing effect (Chiarello & Hoyer, 1988), and those failing to find significant age differences have also failed to find a levels of processing effect (Light & Singh, 1987). The present study found a combination of age effects and no levels of processing effect, thereby providing additional inconsistencies in the literature.

General Knowledge

The literature regarding implicit conceptual tests has focused on tests such as exemplar generation, and no age differences have generally been found (Light & Albertson, 1989). Recently, Small et al. (1995) and Poisson (1996) examined age differences on the general knowledge test. Poisson (1996)

found significant age differences on the general knowledge test, yet Small et al. (1995) failed to find age differences using similar general knowledge questions. Poisson (1996) used the orienting tasks of pleasantness rating and vowel counting, compared to lexical decision used by Small et al. (1995). Based on these results, it was hypothesized that age differences would not be found on the general knowledge test and that all age groups would demonstrate a significant amount of priming.

Unexpectedly, the hypothesis concerning the lack of age differences on the general knowledge test was not verified. The finding of a significant age effect is inconsistent with Small et al. (1995) who found that the general knowledge test did not demonstrate age effects. Indeed, no age differences were found between the middle age and older adults, yet the young performed significantly better than both of the other age groups. The performance of middle age and older adults was similar to that found by Small et al. (1995). When comparing the performance of young and older adults, the results are more consistent with Poisson (1996), who also found significant age differences between young and older adults on the general knowledge test.

As predicted, in the present experiment, all age groups demonstrated significant priming on the general knowledge test. However, when separate analyses were conducted, the older adults demonstrated significant priming only after the vowel counting task, and the middle age adults failed to demonstrate significant priming after any orienting task. The young evidenced significant priming after all encoding tasks except pleasantness ratings. It is obvious that the young adults were demonstrating more reliable priming than the other age groups, since significant priming was found in almost all conditions, even with the relatively small number of participants per group. The

explanation for the lack of significant priming once the data were analyzed by orienting task may be related to the small degrees of freedom used when examining a group of 16 participants.

Level of processing was not manipulated by Small et al. (1995), yet Poisson (1996) failed to find a significant levels of processing effect for both young and older adults on the general knowledge test. However, Cabeza (1995) demonstrated a significant levels of processing effect for young adults on the implicit conceptual test of general knowledge. Since no age differences were expected on the general knowledge test, all age groups were expected to perform similarly on this task. It was also expected that a significant levels of processing effect would be found.

Contrary to the hypothesis, a reverse depth effect was found on the general knowledge test, for both young and older adults. These results were contrary to Poisson (1996), who failed to find a levels of processing effect for these age groups. The pattern of the results is that of a reverse depth effect, with the less semantic task of vowel counting evidencing a greater amount of priming than the more semantic tasks of generate associate and pleasantness ratings. Cabeza (1995), on the other hand, found significant priming by young adults in the semantic condition but not in the physical condition, which is the normal pattern. Small et al. (1995) proposed that, if a more semantic orienting task were used, then the age differences would be minimized on the implicit conceptual test of general knowledge. In fact, the opposite occurred in the present study, the least semantic task of counting vowels demonstrated a greater amount of priming than the generate associate condition. The reason for the high level of priming following vowel counting may be due to the fact that the participants considered this to be an odd task and they may have processed

more information than normally expected. Also a few of the older adults had to be reminded which letters of the alphabet were vowels. This lack of familiarity may have influenced the older adults performance.

Overall, the vowel counting condition evidenced a greater amount of priming by all age groups. However, on the general knowledge test the middle age adults demonstrated a very low amount of priming compared to the other age groups. The middle age adults evidenced less than half the priming of the young and a substantially lower level of priming than the older adults. In general the middle age adults showed lower levels of priming for each orienting task, yet the pattern resembled that of the other age groups.

The older adults showed a dramatic decline in priming for the lexical decision task. There are various reasons for this, one being the lower education level of older adults. When deciding if the letters form a real word, several of the older adults, and those of middle age to some degree, were not familiar with certain words nor were they confident in their spelling skills. This lack of confidence may have created problems when processing the information. If this were the case, it would be presumed that similar problems would have occurred in Small et al. (1995) and they did not. The young adults in the present study demonstrated a priming score of .20 compared to .05 found by Small et al. (1995). This large difference in priming levels by the young may be responsible for the finding of age differences on the general knowledge test. Both studies found that the middle age adults demonstrated a priming level of .06 after completing the lexical decision task. However, the older adults in Small et al. (1995) demonstrated a slightly higher level of priming, .04, compared to .01 in the present study. The significant age differences found in the present study may be explained by the fact that the younger adults

performed at higher levels than those in Small et al. (1995) and the older adults performed at lower levels.

Once again, age differences were found on the general knowledge test contrary to Small et al. (1995). A reverse levels of processing effect was present, contrary to previous literature. Several possible explanations are discussed in relation to the various theoretical approaches.

Cued Word Recall

The majority of studies that have examined cued word recall have found significant age differences (Chiarello & Hoyer, 1988). Hultsch et al. (1991) and Small et al. (1995) also examined word recall of young, middle age and older adults, and found that the middle age group performed better than the older adults, yet they did not recall as many words as the younger adults. Based on these findings it was hypothesized that significant age differences would be found between the older adults and both the middle age and young adults on cued word recall.

Cued word recall performance of older adults was indeed impaired, when compared to that of the younger adults. However, middle age adults performed the same as the older adults, indicating a possible impairment in explicit memory that occurs in middle age. The finding that young adults recalled significantly more than older adults is consistent with Chiarello and Hoyer (1988). However, finding that the middle age adults did not perform better than the older adults is contrary to the results of Hultsch et al. (1991) and Small et al. (1995).

A levels of processing effect was also expected on the cued word recall test. Chiarello and Hoyer (1988) were also interested in the levels of processing effect and found that semantic encoding facilitated cued recall in both young

and older adults. In the present study, participants who rated the words for pleasantness and vowel counting performed equivalently, and these two conditions produced greater recall than the other orienting conditions. Chiarello and Hoyer (1988) discovered a much larger encoding effect on the cued word recall test than on the word stem completion test, with pleasantness rating producing greater recall than vowel counting. The results of this study did not follow the same pattern; the more semantic task of generate associate did not produce as much recall as the more perceptual task of counting vowels. According to previous research, the more semantic conditions of generate associate and pleasantness should have produced significantly higher recall than the vowel counting and lexical decision conditions (Craik, 1986).

Once again the nature of the orienting tasks may have affected performance on the explicit test. The participants were not familiar with the tasks and therefore the novelty of counting vowels may have affected performance. The words that were used for the cued recall test were from various categories: such as flowers, boats, weather, etc. The majority of these words would not have a specific meaning for the participants and they may not have made meaningful associations with these words.

The explicit test demonstrated impairments as expected. The finding that performance on both implicit and explicit perceptual tests were impaired may point to a general deficit in perceptual processing for middle age and older adults. Unfortunately, the pattern of the levels of processing effect is inconsistent with previous literature.

Fact Recall

A variety of fact recall tests can be used to test recall. Hultsch et al. (1991) and Small et al. (1995) both used fact recall tests as a measure of semantic

memory than of explicit memory. For example, the questions are provided to the participant and they must rely on their semantic knowledge to answer the questions. In the present study, the answers to the questions were presented to the participants in a study phase and the questions were later given as cues for recall. Therefore, one must be cautioned when comparing the results of the present study with prior results. Both Hultsch et al. (1991) and Small et al. (1995) found that middle age adults performed better than young and older adults, and surprisingly, the older adults performed better than the young adults. These results are contrary to what is normally found on explicit memory tests, which leads one to conclude that these tests are examining semantic memory. Based on previous work with explicit memory tests (Craik, 1986), it was hypothesized that significant age differences would be found on fact recall.

Contrary to expectations, no significant age differences were found on the fact recall test. The lack of age differences may be due to differences in factual knowledge that each age group possessed. For example, the older and middle age adults have more world experience and therefore, the amount of knowledge they have acquired may benefit them on this type of test when compared to the cued recall test where they have to rely solely on their memory for words that have no personal meaning or relevancy. The younger adults demonstrated explicit memory performance that was based solely on memory and no meaningful connections were made between the material and the test. The fact recall test relies heavily on semantic memory. To answer the questions the participants must recall previously studied words, however, they may access general knowledge without making reference to the specific contextual details. In the past it has been suggested that older adults do not show decrements in this type of memory performance, and in fact, they may outperform young adults

in some instances (Hultsch et al., 1991).

To further extend the study by Small et al. (1995), a levels of processing manipulation was added to this experiment. Cabeza (1995) found a significant levels of processing effect by young adults on a fact recall test. These results combined with several previous findings of levels of processing effects on explicit memory tests (Craik, 1986) led to the hypothesis that a significant levels of processing effect would be found.

The way in which the words were studied did have an effect on fact recall performance. As expected, those who studied in the most semantic task of generate associate recalled more words than those who studied in any other condition, except lexical decision. In the past it has been suggested that explicit memory tests demonstrate a levels of processing effect (Craik, 1986) and this claim was further substantiated by the present results. Given the pattern of results that Small et al. (1995) found for the fact recall test, it is not surprising that once a more semantic orienting task was used, age differences were minimized.

It is interesting that the unusual pattern of levels of processing effects that were present on general knowledge and cued recall were not observed on fact recall. The absence of this pattern leads one to the conclusion that the manner in which the tests were administered was not responsible for the odd pattern of results. For example, if a flaw in the procedure was responsible for the odd pattern of levels of processing effect, since this explanation would suggest that this pattern would be expected to appear for every test. In fact the pattern, although nonsignificant, on the word stem completion also followed a normal pattern, which further validates the experimental procedures.

The second explicit memory test did not demonstrate significant age effects,

which was contrary to expectations. Deficits were present on the implicit conceptual test but not on the explicit conceptual test. As expected, a levels of processing effect was found, with the most semantic task revealing the greatest amount of recall.

Correlations

For the young adults, the two implicit memory tests were negatively correlated. The young adults did not demonstrate any other significant correlations between test measures. The relatively small variation in the amount of education or the vocabulary scores for the young adults may account for the lack of a significant correlation of these variables with any of the test measures. Middle age adults revealed a significant positive correlation between general knowledge and the fact recall test. Inconsistent with Hultsch et al. (1991), older adults demonstrated significant positive correlations between the word stem completion and general knowledge tests. Older adults also evidenced a positive correlation between performance on the general knowledge test and the fact recall test.

Interestingly, age differences were found on the implicit test and not on the explicit test. This is the opposite of that reported by Small et al. (1995) who did not find any significant correlations between the general knowledge and any of the other test measures, for all age groups. However, the fact recall test used by Small et al. (1995) was a semantic test and did not directly measure explicit memory. Therefore, a correlation between the general knowledge and fact recall test may not have been possible using the different testing technique.

Explicit Contamination

If explicit retrieval was being used on implicit tests, some degree of positive correlation would be expected between the implicit and explicit tests. Word

stem completion was not correlated with any of the explicit memory tests for any age group. Therefore, it is highly unlikely that explicit retrieval strategies are being used on the implicit perceptual test.

As discussed previously, general knowledge was significantly correlated with the fact recall test for middle age and older adults, but not for the young adults. Since the tests were correlated it brings in the possibility of explicit contamination. However, as noted previously, concerns about participants using explicit retrieval on an implicit memory test are usually raised in the context of greater priming in the young adults than in older adults. Older adults are generally found to demonstrate impaired explicit memory performance, they would not benefit as much from the use of explicit retrieval strategies. One must also remember that no significant age differences were found on the fact recall, which implied that the young adults' explicit memory performance was not greater than that of the older adults. Once again the explicit contamination explanation does not account for the findings of the present research.

Small et al. (1995) point out that the way in which the words are originally presented to the participants may also play a role in the possibility of explicit contamination. When a more semantic orienting task is used, more time is required, thereby allowing for the possibility that the participants may become aware of the need for future recall of the studied information. In the present study, four orienting tasks were used that varied in the semantic nature of the task. However, on the word stem completion test, the orienting task did not have an effect on performance. If explicit retrieval processes were being used, one would expect that those in the more semantic condition of generate associate would demonstrate improved performance. This was not the case in the present experiment: Thus, there data do not support the conclusion that

word stem completion was contaminated by explicit retrieval processes.

As far as the manner in which the words were initially studied for the general knowledge test, the vowel counting condition evidenced the greatest amount of priming. Therefore, the notion of the semantic task influencing performance via explicit contamination is not likely.

Effect Size

To address the issue of inconsistent age-related differences on implicit memory tests in terms of sample size, this sample was relatively large, with 64 participants in each age group, and significant age differences were found on both the word stem completion and general knowledge tests. However, Small et al. (1995) had age groups that consisted of 82, 197, and 124 participants per group and did not find significant age differences on the general knowledge test. Therefore, even large sample sizes may not demonstrate significant age differences on implicit memory tests.

According to Blaxton (1989) and Small et al. (1995), priming on the general knowledge test would increase if more semantic orienting tasks were used. Small et al. (1995) demonstrated a level of priming on general knowledge in the range of .04 to .06 using a lexical decision task at study. In the present study, a lexical decision task was used and the priming scores were in the range of .01 for older adults, .06 for middle age, and .20 for the young adults. The middle age adults in both studies are performing in the same range, yet the young adults in the present study demonstrated a significantly greater amount of priming than those used by Small et al. (1995). This is what was expected, since the young adults in Small et al. (1995) demonstrated a low level of priming which may have led to the lack of significant age differences.

When the more semantic orienting task of generate associate was used,

priming scores fell in the range of .03 to .08. These values are more comparable to those of Small et al. (1995), yet they are lower than the priming scores found after the lexical decision task that was thought to require less meaningful processing. Therefore, the completion of semantic orienting tasks did not increase the amount of priming over that produced in the lexical decision task, except for the older adults. It is possible that this task allowed them to make more meaningful connections with the studied words and therefore, when asked to answer the questions, the words may be more readily available.

There was a significant effect of age on baseline levels for the word stem completion test, with the young adults completing more of the stems with baseline items than the older adults. Hultsch et al. (1991) and Small et al. (1995) also found significant differences in baseline levels between the young and the older adults. However, they found that the middle age and older adults were more likely to complete the stem with baseline items than were the young adults. On the other hand, Chiarello and Hoyer (1988), Davis et al. (1991), and Light and Singh (1987) all failed to find significant effects of age on baseline levels for word stem completion. The fact that significant age differences were found for baseline items does not qualify the finding of significant age differences in performance on word stem completion, since Chiarello and Hoyer (1988) and Davis et al. (1990) also found significant age differences even when the baseline completion rates were comparable across age groups.

On the general knowledge test, all of the age groups completed a similar number of baseline items with non-studied words. Small et al. (1995) found that the middle age group completed more baseline items with non-studied items than did both the young and older adults. Even though the middle age

adults completed more baseline items correctly, no age effects were found on priming scores on the general knowledge test (Small et al., 1995). In the present study, the baseline levels were much lower overall, ranging from .15 to .19, compared to .22 to .33 reported by Small et al. (1995). These higher baseline levels may be responsible for the lower magnitude of priming that was reported by Small et al. (1995).

Theoretical Approaches

According to the activation hypothesis, priming was expected to occur on implicit memory tests since priming only requires the activation of an existing representation in memory (Graf & Mandler,1984). However, older adults' performance on both explicit tests was expected to be impaired, since these tests were believed to require more elaborative encoding of contextual information during study. Contrary to these predictions, no significant effects of age were found on the fact recall test, whereas significant effects of age were found on both implicit memory tests. In order for participants to perform normally on the fact recall test, more elaborative encoding of contextual details was required, and if this was indeed done, then this hypothesis would predict that implicit memory performance should also have been normal. Therefore, this model does not adequately account for the findings of this study.

The notion of lack of environmental and retrieval support was carried further by Light and Singh (1987) when they examined performance on word stem completion and cued recall, both tests which required the participants to complete three letter word stems. They found reliable age differences for cued recall but not for word stem completion, which suggested that the critical variable was not strictly the amount of retrieval support, but also intention to remember at test. In the present study both the word stem completion and cued

word recall tests demonstrated reliable age differences, which may suggest that the intention to remember as well as environmental support are both important in finding age effects.

When the data were analyzed according to age group, no significant correlations were found between the two explicit tests of memory. Hultsch et al. (1991) found fact recall and word recall to be correlated for all age groups. However, their fact recall test was more of a semantic memory test than an explicit test. Nonetheless, important theoretical applications may be derived from these correlations. For example, if the two types of explicit tests were correlated, it would seem to imply that the same type of processing was involved in each task, or that they both were subserved by the same memory system. The lack of a correlation for the participants in the present study may be due to floor or ceiling effects. The young adults especially, performed extremely well on the cued word recall with an average of 92% of the words recalled, compared to fact recall, with an average of 61% of the words recalled. Performance on the cued recall test was so high that it restricted the range and it would be extremely difficult to derive a significant correlation in this situation. Since performance on general knowledge and fact recall correlated significantly, it may be assumed that the same processes do indeed underlie each test.

According to Tulving and Schacter (1990) and their memory systems hypothesis, different forms of priming rely on different memory systems. For example, priming on the general knowledge test is semantic in nature. When presented with new items the memory system will update its previous information or make the necessary modifications to allow the new information to be assimilated into memory. Word stem completion, which is considered

perceptual priming, on the other hand, relies on the physical features of the words. For example, when a word is presented, its physical features are analyzed and compared to information that is already stored in the PRS. If the test items match those studied items that are already present in the PRS, then priming will occur.

In the present study both implicit memory tests demonstrated significant age differences, thereby contradicting reports of a dissociation between implicit tests (Small et al., 1995). Nonetheless, the two implicit tests were negatively correlated for younger adults, and positively correlated for the older adults. According to this finding, performance on general knowledge was related to performance on word stem completion, at least for young and older adults. In contrast, Small et al. (1995) failed to find significant correlations between the two implicit tests, yet they found age differences on word stem completion and not on general knowledge, which clearly identified a dissociation between the two tasks. This finding was not replicated in the present study. Since both implicit tests demonstrated age differences, it is possible that the same memory system is responsible for performance on implicit memory tests. It is noteworthy that middle age adults also demonstrated significant age differences on the implicit tests, and therefore, performance on implicit memory tests may begin to differ earlier in life than previously suggested.

There was a dissociation between the two conceptual tests: No significant age differences were present on the explicit fact recall test, yet significant age differences were found on the implicit general knowledge test. If both tasks were assumed to demonstrate performance from the same memory system, then performance on each test would have been expected to reveal a similar pattern of results. The correlational data, however, did not appear to provide

support for a dissociation between the general knowledge and fact recall tests. Specifically, the older adults demonstrated a strong correlation between general knowledge and fact recall scores. These two measures would not be expected to correlate with one another if a strong dissociation was present. It is possible that performance on the fact recall test was based more on semantic memory, and therefore, the age differences that were predicted were minimized.

This proposed dissociation between conceptual implicit and explicit tests may call into question some of the claims of Tulving and Schacter's (1990) memory systems view. According to their hypothesis, all forms of conceptual priming were expected to rely upon the same memory system, one which was presumed separate from the system responsible for perceptual priming. Therefore, the memory systems view is called into question by the present results. Yet, if one considers the possibility of fact recall performance being enhanced via semantic memory, then the results of this study may not be as problematic for the memory systems hypothesis.

The claims of the memory systems approach, which predicted significant priming on the word stem completion test, were supported in this experiment. A significant amount of priming was expected for all age groups since word stem completion is a perceptual test which relies on the PRS, and it is believed that the PRS remains intact throughout the life span. However, significant age differences were found on word stem completion, which leads one to believe that there is some sort of breakdown in the functioning of the PRS. Even though older adults were capable of performing the word stem completion test, their baseline performance was not equivalent to that of the younger adults.

The results on the general knowledge test may provide support for the memory systems view, depending on which interpretation of this approach one

adopts. Since performance on both implicit memory tests demonstrated age differences, there are various possible explanations. For instance, the memory systems view stated that the implicit perceptual test relies on the PRS and the implicit conceptual test relies on a semantic memory system. In order for the data to be interpreted according to this theory, one would have to acknowledge impairments of both memory systems due to the aging process.

Further problems arise for the memory systems approach when attempting to explain the findings of deficits on the implicit conceptual test but not on the explicit conceptual test. This may lead to the suggestion that separate memory systems are underlying the two conceptual tests. As mentioned previously, the semantic nature of the fact recall test may have led to enhanced performance for the older adults, and therefore, the apparent dissociation among conceptual tests may be overstated.

The transfer appropriate processing approach also predicted significant priming on the word stem completion test. According to the transfer appropriate processing approach, priming on the word stem completion test was due to the amount of perceptual processing that occurred at study. If the processing at study matches the processing at test, then performance will be optimal. Regardless of the orienting task that is used, the information is processed perceptually to some degree. Even for the most semantic orienting task of generate associate, the participants must examine the physical features of the words at study. Once this processing has taken place, the information is stored in memory and when the word stems are presented at test, the perceptual match is capable of being made. The same principles apply to the general knowledge test: Significant priming is expected when the words were studied for meaning and were later tested for meaning.

Unfortunately, this approach does not provide much assistance in explaining the age differences found on the implicit tests. It is possible that as adults get older, the way in which they process information may change, they become slower or less effective at processing the information (Salthouse, 1985). These changes that accompany aging may be responsible for the age differences found on the word stem completion test.

The transfer appropriate processing approach states that when processing at study matches processing at test then performance will be optimal. Therefore, on a conceptual test, when the material is studied conceptually, instead of perceptually, the performance will be enhanced and a depth effect will occur. The word stem completion test failed to demonstrate a significant levels of processing effect, which is not surprising given the previous claims that perceptual tests do not exhibit such effects (Hamann, 1990), but is contrary to the conclusions of Brown and Mitchell (1994). However, the pattern of the levels of processing effect was as expected, with the semantic tasks producing greater priming than the physical tasks, even though the effect was not significant.

The general knowledge test and cued word recall test demonstrated findings that were inconsistent with the transfer appropriate processing approach. Priming on the general knowledge test was expected to be greatest following the generate associate and pleasantness conditions. However, the vowel counting condition evidenced the greatest amount of priming. This is at odds with the predictions of the transfer appropriate processing model. The cued word recall test also demonstrated improved performance in the vowel counting condition, although this is not as surprising as the general knowledge result, since the vowel counting task focuses on physical features and so does the

cued recall test. To add even further confusion, the fact recall test evidenced the greatest amount of recall subsequent to the generate associate condition. In summary, it appears that no one theory is sufficient in accounting for the findings of this experiment.

No clear explanation exists for the odd findings with the levels of processing effect on the general knowledge test. As previously mentioned it is possible that the novelty of counting vowels may have contributed to the increased priming following that orienting task. The nature of the words used as answers to the general knowledge questions may have also contributed to the discrepant findings, as many of the answers to the questions were unusual words. The infrequent usage of these words or the fact that several words had more than 4 vowels in them may be operating in some way to alter performance. However, the same reverse depth effect was also found on the cued recall test, where the words were not unusual. Therefore the novelty of the words is not an adequate explanation of the odd phenomenon that has occurred. There appears to be no clear cut explanation for these reverse depth effects. They may have to do with the way in which the participants performed the various orienting tasks, as they may not have processed the information in the appropriate manner.

The findings regarding age differences did not replicate Small et al. (1995), since the present study found age differences on both the word stem completion and general knowledge tests. Small et al. (1995) stated that the general knowledge test would not demonstrate significant age differences, and they appeared to imply that the use of a more semantic orienting task would improve the older adults' performance on the general knowledge test. This claim was not verified in the present study; in fact, a reverse depth effect was found. The failure to replicate Small et al.'s (1995) findings on the general knowledge test

is not due to the type of materials used, since the two studies used the same general knowledge questions, as well as the same nonwords for the lexical decision task.

Another possible reason for the failure to replicate Small et all. (1995) was the low level of performance demonstrated by their young adults on the general knowledge test. The level of priming reported for their young adults was relatively low in comparison to that in the present study. On the word stem completion test, similar levels of priming were found for the young adults in both studies. Therefore, the young adults in Small et al. (1995) were performing equivalently to our young adults on the word stem completion test, but for some reason their performance on the general knowledge test was affected. If the young adults were performing at the same level as in the present study, then age differences may have appeared in Small et al. (1995) for the general knowledge test.

To summarize, age differences were found between the young and both the middle age and older adults on both word stem completion and general knowledge tests, which indicated an overall impairment of performance on implicit memory tests. Previous findings in regards to word stem completion have been mixed, with approximately half of the studies reporting age differences and half failing to find significant age effects. Unfortunately, the results of the present study do not aid in resolving the previous inconsistencies. Since the procedures in the majority of the studies are virtually identical, it may be that the characteristics of the participants may be creating some of the variability in the findings.

The main goal of the present research project was to replicate the findings of no significant age differences on the general knowledge test. Small et al.

(1995) were the only researchers to examine this type of conceptual test with middle age and older adults. Therefore, unlike word stem completion, the general knowledge test has not been extensively examined. The problem with suggesting future work using the general knowledge test is that we may end up in the same predicament as with the word stem completion test. Nonetheless, it is important to determine whether age differences are present only on perceptual tests or if conceptual implicit tests also show decrements.

The practical significance of this type of research is to better understand the capabilities of older adults. They may indeed possess the capacity to perform normally on some implicit memory tests and not on others. The way in which implicit memory is tested might ultimately influence the older adults' performance, and therefore their true capabilities may be overlooked by certain test measures. The type of implicit memory performance that is considered normal for an older adult is important, since they are often used as control groups for other studies (i.e. Alzheimer disease research). Therefore, it is important to establish whether age differences do exist between older adults and the young before comparing the older adults' performance with a clinical population.

Future research is also needed to address the performance of middle age adults, since significant age differences were found between middle age and young adults. It appears that implicit memory performance may begin to show age differences much earlier than previously reported. It is not only implicit memory performance that demonstrated significant age differences between the young and older adults, but also the explicit test of cued word recall. Therefore, the middle age group should be further studied in order to determine if performance on both implicit and explicit memory tests differs significantly from

the young adults, or if the middle age adults are performing similarly to the older adults.

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Table 1

Summary of Studies Examining Age Differences in Implicit Memory Tests

Test Type	Study Task	Design*	Results
Word Stem Completion			
Chiarello & Hoyer, (1988)	PL, VC	B	age differences, LOP
Davis et al. (1990)	PL	B	age differences
Friedman, Snodgrass, & Ritter (1994)	AN, AE	B	no age differences, LOP
Hultsch et al. (1991)	LDT	W	age differences
Howard, Fry & Brune, (1991)	SE	W	age differences
	CS	W	no age differences
	CS	W	age differences
Java & Gardiner, (1991)	GA, LW	W	no age differences, no LOP
Light & Singh, (1987)	PL, VC	B	no age differences, no LOP
	PL, VC	B	no age differences
Small et al. (1995)	LDT	W	age differences
Perceptual Identification			
Light et al. (1992)	PL, CSy	B	no age differences, no LOP
Light & Singh, (1987)	PL, VC	B	no age differences, no LOP
Abbenhuis et al., (1990)	PL, VC	B	age differences
Picture Naming			
Mitchell, (1989)	FP	W	no age differences
Mitchell, Brown, & Murphy, (1990)	FP	W	no age differences

Category Exemplar Generation			
Isingrini et al. (1995)	PL	W	no age differences
Light & Albertson, (1989)	PL	W	no age differences
Homophone Spelling			
Davis et al. (1990)	GI	B	age differences
Rose, Yesavage, Hill, & Bower, (1986)	GI	W	age differences
Other			
Grober et al. (1992) (FA)	CSR	B	age differences
Hashtroudi, Chrosniak, & Schwartz, (1991) (IRT)	RW	B	no age differences
(WI)	RW	B	no age differences
Java, (1992) (AS)	GA	W	no age differences,no LOP
Russo & Parkin, (1993) (PF)	PN	B	age differences
Small et al. (1995) (GK)	LDT	W	no age differences

-AE- Alphabetic Sequence
-AN- Animal Names
-AS- anagram solution
-CS- Create Sentence
-CSR- Cued Selective Reminding
-CSy- Count Syllables
-FA - free association
-FP-Fragmented Picture
-GA- Generate Associate
-GI-General Information Test
-GK- General Knowledge
-IRT - inverted reading task
-LDT- Lexical Decision Task
-LW- Letters in the Word
-PF-Picture Fragmentation
-PL- Pleasantness Rating
-PN -picture naming
-RW- Read Words
-SE- Sentence Expansion
-VC- Vowel Comparison
-WI - Word Identification

*B=between-subjects; W=within-subjects

Table 2

Demographic Characteristics of the Sample

Variable	Young Adults 19 - 33 yrs	Middle Adults 41 - 64 yrs	Older Adults 65 - 86 yrs
Age	M=19.56 (1.84)	M=54.06 (7.01)	M=71.82 (5.44)
Gender	Males=23 Females=41	Males=27 Females=37	Males=22 Females=42
Years of Education	M=14.12 (0.37)	M=13.32 (3.13)	M=11.42 (3.05)
Vocabulary	M=45.87 (5.88)	M=45.95 (9.66)	M=44.48 (9.33)
MMSE	NA	NA	M=27.32

Note: Standard deviations are reported in parentheses.

Table 3

Means and Standard Deviations of Priming Scores on Word Stem Completion According to Age and Orienting Task.

Age	Generate Associate	Pleasant Rating	Vowel Counting	Lexical Decision	Mean	Baseline
Young						
	4.49	3.99	3.12	3.49	3.77	2.87
	(2.77)	(2.09)	(2.70)	(2.30)		
Middle Age						
	3.11	2.42	2.79	2.36	2.67	2.51
	(3.14)	(2.73)	(2.65)	(1.47)		
Older						
	2.56	2.63	2.06	1.75	2.25	2.12
	(2.20)	(1.91)	(2.40)	(2.18)		
Mean	3.39	3.01	2.66	2.53	----	

Note: Standard deviation values are reported in parentheses.

Table 4

Means and Standard Deviations of Priming Scores on General Knowledge According to Age and Orienting Task.

Age	Generate Associate	Pleasant Rating	Vowel Counting	Lexical Decision	Mean Baseline	
Young						
	1.68	1.56	4.06	4.00	2.82	3.37
	(2.48)	(3.11)	(2.72)	(3.93)		
Middle Age						
	0.69	0.19	1.94	1.19	1.00	3.81
	(2.63)	(2.85)	(4.82)	(4.84)		
Older						
	1.25	0.50	3.06	0.25	1.26	3.06
	(2.56)	(2.38)	(4.19)	(2.92)		
Mean	1.21	0.75	3.02	1.81	—	

Note: Standard deviation values are reported in parentheses.

Table 5

Means and Standard Deviations on Cued Recall

According to Age and Orienting Task.

Age	Generate Associate	Pleasant Rating	Vowel Counting	Lexical Decision	Mean
Young	17.87 (1.45)	19.31 (0.79)	19.37 (0.80)	16.87 (2.39)	18.35
Middle Age	13.93 (4.52)	16.75 (2.56)	17.06 (2.69)	12.93 (3.69)	15.17
Older	14.31 (2.91)	15.75 (3.33)	16.18 (4.27)	10.68 (4.94)	14.23
Mean	15.37	17.27	17.54	13.50	-------

Note: Standard deviation values are reported in parentheses.

Table 6

Means and Standard Deviations on Fact Recall

According to Age and Orienting Task.

Age	Generate Associate	Pleasant Rating	Vowel Counting	Lexical Decision	Mean
Young	14.37 (2.70)	10.25 (3.06)	11.06 (2.90)	13.50 (2.80)	12.29
Middle Age	13.81 (4.26)	10.06 (4.20)	12.18 (4.37)	14.31 (3.79)	12.59
Older	14.18 (3.27)	10.06 (4.13)	11.87 (4.60)	11.43 (3.55)	11.89
Mean	14.12	10.12	11.70	13.08	------

Note: Standard deviation values are reported in parentheses.

Table 7

Correlations of All Memory Test Measures for the Young Adults

	Word Stem Completion	General Knowledge	Cued Recall	Fact Recall
General Knowledge	-.249 *	-----		
Cued Recall	.150	-.089	-----	
Fact Recall	.021	.022	-.053	-----
Education	-.088	.072	-.046	-.215

* $p<.05$

Note: Partial correlations controlling for the effect of vocabulary.

Table 8

Correlations of All Memory Test Measures for the Middle Age Adults

	Word Stem Completion	General Knowledge	Cued Recall	Fact Recall
General Knowledge	-.048	------		
Cued Recall	.084	.011	------	
Fact Recall	.165	.406 **	-.090	------
Education	.115	.126	-.016	.129

** p<.001

Note: Partial correlations controlling for the effect of vocabulary.

Table 9

Intercorrelations of All Memory Test Measures for the Older Adults

	Word Stem Completion	General Knowledge	Cued Recall	Fact Recall
General Knowledge	.276 *	-----		
Cued Recall	.130	.226	-----	
Fact Recall	.092	.260 *	.011	-----
Education	.176	-.009	.206	.011

* $p<.05$

Note: Partial correlations controlling for the effect of vocabulary.

Appendix A

Items used for each Test Measure

Word Stem Completion

List #1

1. slate (sla___)
2. bleach (ble___)
3. fasten (fas___)
4. throw (thr___)
5. accurate (acc___)
6. knitting (kni___)
7. purify (pur___)
8. individual (ind___)
9. meadow (mea___)
10. sentence (sen___)
11. template (tem___)
12. valium (val___)
13. diagram (dia___)
14. fact (fac___)
15. tartar (tar___)
16. grape (gra___)
17. mildew (mil___)
18. shop (sho___)
19. prayer (pra___)
20. sandwich (san___)

List #2

1. ball (bal___)
2. various (var___)
3. across (acr___)
4. surround (sur___)
5. exhale (exh___)
6. hard (har___)
7. lease (lea___)
8. vendor (ven___)
9. quantity (qua___)
10. post (pos___)
11. visitor (vis___)
12. real (rea___)
13. perfect (per___)
14. cabin (cab___)
15. brazier (bra___)
16. weak (wea___)
17. forget (for___)
18. medicine (med___)
19. visitor (vis___)
20. latitude (lat___)

Practice Words: quebec and sorcerer
All words have frequency between 13 and 20

General Knowledge

1. What disease is characterized by bleeding gums and results from a vitamin deficiency ?

_____

2. In what chess play do you move a king two squares toward a rook and move the rook to the square next past the king ?

_____

3. What is any space absolutely devoid of matter ?

_____

4. What was Willie Loman's profession in the famous play by Arthur Miller ?

_____

5. What is another name for the lasso used by a cowboy to rope livestock ?

_____

6. What is the proper term for German Measles ?

_____

7. What would you be in if you did an Eskimo roll ?

_____

8. What is the large redwood tree found in northern California ?

_____

9. What animal is also called a wallaby ?

_____

10. What nuclear process takes place in an H-bomb ?

_____

11. What term refers to a speech or soliloquy made by an actor in a play ?

_____

12. What animal is also known as an earth pig, ant bear, and cape anteater ?

_____

13. What is the name of the legendary one-eyed giant in Greek mythology ?

_____

14. What is the negative electrode of a battery called ?

_____

15. What is the syrup drained from raw sugar ?

_____

16. What was the name of the imaginary country in Sir Thomas More's most famous book ?

_____

17. What is the name of a limestone deposit rising from the bottom of a cave?

_____

18. What sport uses plugs and leaders ?

_____

19. What collective term refers to the body of people represented by a given politician ?

_____

20. What German city is famous for the scent it produces ?

_____

21. What type of organisms are barnacles and leeches ?

_____

22. What venomous serpent is known as the "gentleman among snakes" ?

_____

23. What term refers to the part of an insect's body between the head and the thorax ?

_____

24. What is the name of a wheeled hospital cot ?

_____

25. What are the fragments of ashes from a fire called ?

_____

26. What is the Taj Majal made of ?

_____

27. What is the basic flavouring of Kuhlua ?

_____

28. What appears when the sun activates your melanocytes ?

_____

29. What metal makes up 10% of yellow gold ?

_____

30. What term describes the speed at which the position of an object changes ?

_____

31. Which of the seven dwarfs comes first alphabetically ?

_____

32. What sort of cartoon distorts a person's features for satirical purposes ?

_____

33. What is a person called who doubts the existence of a supreme God ?

_____

34. What is the name of the organ that produces insulin ?

_____

35. What small blood vessel supplies oxygen and nutrients to cell tissues ?

_____

36. What was the name of Armstrong and Aldrin's lunar module ?

_____

37. According to folklore, what bird's feathers should never be used in a house as decoration ?

_____

38. What kind of sports team was reunited in Jason Miller's That Championship Season ?

_____

39. What name is given to a light hearted five-line poem ?

_____

40. What is Antonio's profession in Shakespeare's play that takes place in Venice ?

_____

Answers to General Knowledge Questions

1. scurvy
2. castle*
3. vacuum*
4. salesman
5. lariat*
6. rubella
7. kayak
8. sequoia*
9. kangaroo
10. fusion*
11. monologue*
12. aardvark*
13. cyclops*
14. cathode
15. molasses
16. utopia
17. stalagmite*
18. fishing
19. constituency
20. cologne*
21. parasite*
22. rattlesnake
23. abdomen
24. gurney*
25. cinder*
26. marble
27. coffee*
28. freckles
29. copper*
30. velocity*
31. bashful
32. caricature*
33. agnostic
34. pancreas
35. capillary
36. eagle*
37. peacock*
38. basketball
39. limerick
40. merchant*

Note: * indicates item appears on list number one.

Cued Word Recall
List #1

A kind of cloth: cotton (cot___)
wool (woo___)
silk (sil___)
rayon (ray___)

A unit of time: minute (min___)
second (sec___)
year (yea___)
century (cen___)

A kind of money: dollars (dol___)
nickels (nic___)
dimes (dim___)
pennies (pen___)

A natural earth formation: mountain (mou___)
hill (hil___)
river (riv___)
rock (roc___)

A type of human dwelling: house (hou___)
apartment (apa___)
tent (ten___)
cave (cav___)

List #2

A type of ship: sailboat (sai___)
destroyer (des___
cruiser (cru___)
submarine (sub___)

A flower: rose (ros___)
tulip (tul___)
daisy (dai___)
violet (vio___)

A science: chemistry (che___)
physics (phy___)
psychology (psy___)
biology (bio___)

A chemical element: oxygen (oxy___)
hydrogen (hyd___)
nitrogen (nit___)
sodium (sod___)

A weather phenomenon: hurricane (hur___)
tornado (tor___)
rain (rai___)
snow (sno___)

Fact Recall
List #1

1. What is the name of an airplane without an engine ?

_____

2. What is the name of the rubber object that is hit back and forth by hockey players ?

_____

3. What is the name of the ship that carried the pilgrims to America in 1620 ?

_____

4. What is the name for the inability to sleep ?

_____

5. What is the name of the spear-like object that is thrown during a track meet ?

_____

6. What is the term for hitting a volleyball down hard into the opponents' court ?

_____

7. What is the name of the bird that cannot fly and is the largest bird on earth ?

_____

8. What is the name of the largest ocean on earth ?

_____

9. What is the name of a young sheep ?

_____

10. What breed of cat has blue eyes ?

_____

11. What is the name of the three-leaf clover that is the emblem of Ireland ?

_____

12. What is the last name of the author of the book "1984" ?

_____

13. What is the last name of the man who invented the phonograph ?

_____

14. What is the name of the collarbone ?

_____

15. What is the name of the constellation that looks like a flying horse ?

_____

16. What is the last name of the man who first studied genetic inheritance in plants ?

_____

17. In which city does the Cotton Bowl take place ?

_____

18. Which sport uses the terms "stones" and "brooms" ?

_____

19. What was the name of King Arthur's sword ?

_____

20. What was the last name of the female star of the movie Casablanca ?

_____

List #2

1. Which precious gem is red ?

_____

2. What is the name of the remains of plants and animals that are found in rock ?

_____

3. What is the name for a medical doctor who specializes in diseases of the skin ?

_____

4. What is the name of the thick layer of fat on a whale ?

_____

5. Which planet was the last to be discovered ?

_____

6. For which country is the yen the monetary unit ?

_____

7. What is the name of the desert people who wander instead of living in one place ?

_____

8. What is the name of the palace in London in which the Monarch of England resides ?

_____

9. What is the name of Roy Rogers' horse ?

_____

10. What is the last name of the woman who began the profession of nursing ?

_____

11. What is the name of the hillbilly family that had a famous feud with the McCoy family ?

_____

12. What is the name of the navigation instrument used at sea to plot position by the stars ?

_____

13. Who was the most famous Greek doctor ?

_____

14. In what ancient city were the "Hanging Gardens" located ?

_____

15. What is the last name of the husband-wife spies who were electrocuted in 1951 for passing atomic secrets to Russia ?

_____

16. What are people who make maps called ?

_____

17. What is the last name of the inventor of the wireless radio ?

_____

18. What is the capital of Finland ?

_____

19. What is the name of the furry animal that attacks cobra snakes ?

_____

20. What is the last name of the man who proposed the theory of relativity ?

_____

Answers to Fact Recall
List #1

1. glider
2. puck
3. mayflower
4. insomnia
5. javelin
6. spike
7. ostrich
8. pacific
9. lamb
10. siamese
11. shamrock
12. orwell
13. edison
14. clavicle
15. pegasus
16. mendel
17. dallas
18. curling
19. excaliber
20. bergman

List #2

1. ruby
2. fossil
3. dermatologist
4. blubber
5. pluto
6. japan
7. nomads
8. buckingham
9. trigger
10. nightingale
11. hatfield
12. sextant
13. hippocrates
14. babylon
15. rosenbergs
16. cartographers
17. marconi
18. helsinki
19. mongoose
20. einstein

Nonwords for Lexical Decision

univerce (uni___)

chaptur (cha___)

architach (arc___)

wiodchuck (wio___)

pikture (pik___)

treaser (tre___)

snuggel (snu___)

bootes (boo___)

repramand (rep___)

sokker (sok___)

causea (cau___)

migraite (mig___)

jephuardy (jep___)

healioum (hea___)

legislatien (leg___)

inunciate (inu___)

zippelin (zip___)

asyliom (asy___)

ridicuse (rid___)

collegum (col___)

Appendix B

Orienting Tasks and Test Instructions

This experiment is part of a series of experiments in which we hope to learn more about how people process familiar information. You will be asked to perform some straightforward tasks. Each task will be explained to you when we are ready to begin it.

1. Study Trial: Generate Associate

For your first task, I will give you several cards, each containing a single word. Your task is to go through this set of cards and think of a word that you would associate with the presented word. When you have determined an associate for a word, simply call the word out loud. You should then move on to the next card.

You should go through the cards one at a time, assigning a number to each word. When you have completed the entire list, we will move on to the next task.

Do you have any questions?

2. Study Trial: Pleasantness ratings

For your first task, I will give you several cards, each containing a single word. Your task is to go through this set of cards and rate each word for its pleasantness. If the word has a very pleasant meaning, you should assign it a high number. If the word has a very unpleasant meaning, you should assign it a low number. You can use this scale to help you assign numbers. (put scale on table in front of S). To illustrate, if you see the word "LOVE", you might assign it the number 7 because it has a very pleasant meaning. If you see the word "HATE", you might assign it the number 1 because it has a very unpleasant meaning. When you have determined a pleasantness rating for a word, simply call the number out loud. You should then move on to the next card.

You should go through the cards one at a time, assigning a number to each word. When you have completed the entire list, we will move on to the next task.

Do you have any questions?

3. Study Trial: Vowel Counting

For your first task, I will give you several cards, each containing a single word. Your task is to go through this set of cards and count the number of vowels in each word. When you have counted the vowels simply call the number out loud. You should then move on to the next card.

You should go through the cards one at a time, counting the number of vowels in each word. When you have completed the entire list, we will move on to the next task.

Do you have any questions ?

4. Study Trial: Lexical Decision Task

For your first task, I will give you several cards, each containing a string of letters. Your task is to go through this set of cards and determine whether the string of letters on the card is a real word or not. Many of the "real" words in this task are relatively unusual, so it may take you a moment to identify them. Work as quickly as you can while maintaining accuracy. When you have determined if the string of letters is a real word or not, simply call the response out loud.

You should go through the cards one at a time, deciding if the string of letters is a real word or not. When you have completed the entire list, we will move on to the next task.

Do you have any questions?

5. Filler task: Famous names

For your second task, I will give you a page on which I have printed the first name of several people. Your task is to write in a last name so that the entire

name refers to a famous person. In each case, there is more than one famous name that can be generated, however, you should write in the first name that you think of that is a famous name.

Some names will be difficult to complete, but please try to do your best to write in a famous name for each first name that is on the page.

I will give you about 5 minutes to identify as many famous names as you can. After that, we will move on to the next task.

Do you have any questions ?

States of Union:

For your second task, I will given you a page on which I have printed the names of states of the United States. Your task is to write in the names of the remaining states of the United States using the presented states as cues to remember the rest of the states.

Some states will be difficult to remember, but please try to do your best to write in as many states of the United States as possible. After that, we will move on to the next task.

Do you have any questions?

Test Instructions

Word Stem Completion

Here is a another page on which there is a list of the first 3 letters of several words. There are a total of 40 three-letter word stems.

Your task is to go through the list writing in some additional letters to form a real word. You should write these letters in the space provided immediately to the right of each set of 3 letters. It is important that you write in a response for each 3-letter cue and the response you give should always be the first word that comes to mind when you see the 3 letters. There is no time limit on this task, but you should try to go through the list as quickly as possible, making sure that you write in the first word that comes to mind each time.

Remember, complete each 3-letter stem with the first word that comes to mind. Don't worry about spelling errors - do the best that you can.

General Knowledge Questions

Here is a set of questions of the sort found in Trivial Pursuit-like games. There are a total of 40 questions about your knowledge of facts about the world and words that define certain things or ideas.

For each question, please PRINT your answer in the space beneath the question. The answer will never be more than one word long. Don't worry about spelling errors - do the best you can. Some questions are easier than others. Search your memory for the answer. If you think you may know the answer, but are not sure of it, take a guess anyway. There is no penalty for guessing - we are only concerned that you answer as many questions as possible. If, after searching your memory, you are sure you do not know the answer, place an X in the space and proceed to the next question.

Remember, answer each question with your best guess even if you are unsure whether it is correct.

Cued-Word Recall

Here is a another page on which there is a list of the first 3 letters of several words. There are a total of 20 three-letter word stems. All of the 3-letter stems are the first 3 letters of words that you have just seen.

Your task is to use the three letter stems as cues to help you recall the words that you have just studied. You should write these letters in the space provided immediately to the right of each 3 letter cue. If you cannot remember a word that you saw that begins with one of the 3-letter stems, you should then complete the stem with the first word you thought of that begins with those 3 letters. You will have a 4 minute time limit on this task.

Remember, try to complete each 3-letter stem with one of the words that you have just studied. If you cannot remember a word you saw that begins with the 3 letters, then simply write in the first word that came to mind. Don't worry about spelling errors - do the best that you can.

Fact Recall

Here is a set of questions of the sort found in Trivial Pursuit-like games. There are a total of 20 questions about your knowledge of facts about the world and words that define certain things or ideas.

You have just studied a list of words, use the questions provided as cues to recall the studied words. For each question, please PRINT your answer in the space beneath the question. The answer will never be more than one word long. Don't worry about spelling errors - do the best you can. Some questions are easier than others. Search your memory for the answer. If you think you may know the answer, but are not sure of it, take a guess anyway. There is no penalty for guessing - we are only concerned that you answer as many questions as possible. If, after searching your memory, you are sure you do not know the answer, place an X in the space and proceed to the next question.

Remember, try to answer each question with the words you have just studied.

Appendix C
Implicit and Explicit Memory Tests Used

CodeNumber:_____

Word Stem Completion

Here is a another page on which there is a list of the first 3 letters of several words. There are a total of 40 three-letter word stems.

Your task is to go through the list writing in some additional letters to form a real word. You should write these letters in the space provided immediately to the right of each set of 3 letters. It is important that you write in a response for each 3-letter cue and the response you give should always be the first word that comes to mind when you see the 3 letters. There is no time limit on this task, but you should try to go through the list as quickly as possible, making sure that you write in the first word that comes to mind each time.

Remember, complete each 3-letter stem with the first word that comes to mind. Don't worry about spelling errors - do the best that you can.

Examples:

que_____

sor_____

Code Number:_____

Word Stem Completion

sla_____

bal_____

fas_____

acr_____

kni_____

exh_____

pur_____

lea_____

mea_____

qua_____

san_____

vis_____

dia_____

per_____

fac_____

bra_____

gra_____

for_____

sho_____

med_____

ble_____

var_____

thr_____

sur_____

acc_____

har_____

ind_____

ven_____

sen_____

pos_____

tem_____

rea_____

val_____

cab_____

tar_____

wea_____

mil_____

lat_____

pra_____

mag_____

Code Number:_____

General Knowledge Questions

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For each question, please PRINT your answer in the space beneath the question. The answer will never be more than one word long. Don't worry about spelling errors - do the best you can. Some questions are easier than others. Search your memory for the answer. If you think you may know the answer, but are not sure of it, take a guess anyway. There is no penalty for guessing - we are only concerned that you answer as many questions as possible. If, after searching your memory, you are sure you do not know the answer, place an X in the space and proceed to the next question.

Remember, answer each question with your best guess even if you are unsure whether it is correct.

Examples:

What is the capital of Canada ?

_____

What sign of identity is formed by combining the initials of a name ?

_____

1. What disease is characterized by bleeding gums and results from a vitamin deficiency ?

_____

2. In what chess play do you move a king two squares toward a rook and move the rook to the square next past the king ?

_____

3. What is any space absolutely devoid of matter ?

_____

4. What was Willie Loman's profession in the famous play by Arthur Miller ?

_____

5. What is another name for the lasso used by a cowboy to rope livestock ?

_____

6. What is the proper term for German Measles ?

_____

7. What would you be in if you did an Eskimo roll ?

_____

8. What is the large redwood tree found in northern California ?

_____

9. What animal is also called a wallaby ?

_____

10. What nuclear process takes place in an H-bomb ?

_____

11. What term refers to a speech or soliloquy made by an actor in a play ?

_____

12. What animal is also known as an earth pig, ant bear, and cape anteater ?

_____

13. What is the name of the legendary one-eyed giant in Greek mythology ?

_____

14. What is the negative electrode of a battery called ?

_____

15. What is the syrup drained from raw sugar ?

_____

16. What was the name of the imaginary country in Sir Thomas More's most famous book ?

_____

17. What is the name of a limestone deposit rising from the bottom of a cave?

_____

18. What sport uses plugs and leaders ?

_____

19. What collective term refers to the body of people represented by a given politician ?

_____

20. What German city is famous for the scent it produces ?

_____

21. What type of organisms are barnacles and leeches ?

_____

22. What venomous serpent is known as the "gentleman among snakes" ?

_____

23. What term refers to the part of an insect's body between the head and the thorax ?

_____

24. What is the name of a wheeled hospital cot ?

_____

25. What are the fragments of ashes from a fire called ?

_____

26. What is the Taj Majal made of ?

_____

27. What is the basic flavouring of Kuhlua ?

_____

28. What appears when the sun activates your melanocytes ?

_____

29. What metal makes up 10% of yellow gold ?

_____

30. What term describes the speed at which the position of an object changes ?

_____

31. Which of the seven dwarfs comes first alphabetically ?

_____

32. What sort of cartoon distorts a person's features for satirical purposes ?

_____

33. What is a person called who doubts the existence of a supreme God ?

_____

34. What is the name of the organ that produces insulin ?

_____

35. What small blood vessel supplies oxygen and nutrients to cell tissues ?

_____

36. What was the name of Armstrong and Aldrin's lunar module ?

_____

37. According to folklore, what bird's feathers should never be used in a house as decoration ?

_____

38. What kind of sports team was reunited in Jason Miller's That Championship Season ?

---

39. What name is given to a light hearted five-line poem ?

---

40. What is Antonio's profession in Shakespeare's play that takes place in Venice ?

Code Number:_____

Cued-Word Recall

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Remember, try to complete each 3-letter stem with one of the words that you have just studied. If you cannot remember a word you saw that begins with the 3 letters, then simply write in the first word that came to mind. Don't worry about spelling errors - do the best that you can.

Code Number:_____

Cued Word Recall

des_____

vio_____

che_____

nit_____

sno_____

cru_____

psy_____

rai_____

oxy_____

dai_____

hur_____

bio_____

sod_____

ros_____

tor_____

phy_____

hyd_____

tul_____

sub_____

sai_____

Code Number:_____

Cued Word Recall

cot_____

min_____

dol_____

hil_____

apa_____

sil_____

cen_____

roc_____

hou_____

ray_____

sec_____

dim_____

riv_____

ten_____

woo_____

yea_____

nic_____

mou_____

cav_____

pen_____

Code Number:_____

Fact Recall

Here is a set of questions of the sort found in Trivial Pursuit-like games. There are a total of 20 questions about your knowledge of facts about the world and words that define certain things or ideas.

You have just studied a list of words, use the questions provided as cues to recall the studied words. For each question, please PRINT your answer in the space beneath the question. The answer will never be more than one word long. Don't worry about spelling errors - do the best you can. Some questions are easier than others. Search your memory for the answer. If you think you may know the answer, but are not sure of it, take a guess anyway. There is no penalty for guessing - we are only concerned that you answer as many questions as possible. If, after searching your memory, you are sure you do not know the answer, place an X in the space and proceed to the next question.

Remember, try to answer each question with the words you have just studied.

Fact Recall

1. What is the name of an airplane without an engine ?

_____

2. What is the name of the rubber object that is hit back and forth by hockey players ?

_____

3. What is the name of the ship that carried the pilgrims to America in 1620 ?

_____

4. What is the name for the inability to sleep ?

_____

5. What is the name of the spear-like object that is thrown during a track meet ?

_____

6. What is the term for hitting a volleyball down hard into the opponents' court ?

_____

7. What is the name of the bird that cannot fly and is the largest bird on earth ?

_____

8. What is the name of the largest ocean on earth ?

_____

9. What is the name of a young sheep ?

_____

10. What breed of cat has blue eyes ?

_____

11. What is the name of the three-leaf clover that is the emblem of Ireland ?

_____

12. What is the last name of the author of the book "1984" ?

_____

13. What is the last name of the man who invented the phonograph ?

_____

14. What is the name of the collarbone ?

_____

15. What is the name of the constellation that looks like a flying horse ?

_____

16. What is the last name of the man who first studied genetic inheritance in plants ?

_____

17. In which city does the Cotton Bowl take place ?

_____

18. Which sport uses the terms "stones" and "brooms" ?

_____

19. What was the name of King Arthur's sword ?

20. What was the last name of the female star of the movie Casablanca ?

Code Number:_____

Fact Recall

1. Which precious gem is red ?

_____

2. What is the name of the remains of plants and animals that are found in rock ?

_____

3. What is the name for a medical doctor who specializes in diseases of the skin ?

_____

4. What is the name of the thick layer of fat on a whale ?

_____

5. Which planet was the last to be discovered ?

_____

6. For which country is the yen the monetary unit ?

_____

7. What is the name of the desert people who wander instead of living in one place ?

_____

8. What is the name of the palace in London in which the Monarch of England resides ?

_____

9. What is the name of Roy Rogers' horse ?

_____

10. What is the last name of the woman who began the profession of nursing ?

_____

11. What is the name of the hillbilly family that had a famous feud with the McCoy family ?

_____

12. What is the name of the navigation instrument used at sea to plot position by the stars ?

_____

13. Who was the most famous Greek doctor ?

_____

14. In what ancient city were the "Hanging Gardens" located ?

_____

15. What is the last name of the husband-wife spies who were electrocuted in 1951 for passing atomic secrets to Russia ?

_____

16. What are people who make maps called ?

_____

17. What is the last name of the inventor of the wireless radio ?

_____

18. What is the capital of Finland ?

_____

19. What is the name of the furry animal that attacks cobra snakes ?

---

20. What is the last name of the man who proposed the theory of relativity ?