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A

**Memory performance of young and old healthy adults in two processing  
paradigms: Sentence production and sentence construction.**

by

**Joseph Vollaro**

**A dissertation submitted to the Graduate Faculty in Psychology in  
partial fulfillment of the requirements for the degree of Doctor of  
Philosophy, The City University of New York**

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**This manuscript has been read and accepted for the Graduate Faculty in Psychology in satisfaction of the dissertation requirement for the degree of Doctor of Philosophy.**

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**Abstract****MEMORY PERFORMANCE OF YOUNG AND OLD HEALTHY ADULTS IN  
TWO PROCESSING PARADIGMS:  
SENTENCE PRODUCTION AND SENTENCE CONSTRUCTION****By****Joseph Vollaro****Adviser: Wilma A. Winnick, Ph.D**

The performance of young and old adults was compared on tasks requiring different types of processing at encoding. The experimental conditions varied in terms of whether or not a generation component was present and in the amount of elaboration provided to the participant. In Experiment 1, sentence production was employed in which participants were shown a target word, and then required to generate a sentence containing the word. Recognition and word fragment completion memory tests were administered following the study tasks to allow for potential dissociations with age groups and or/processing tasks. We expected that the elaborative encoding induced by sentence production would reduce age group differences normally found on explicit memory tests. In Experiment 2, sentence construction was employed in which participants were given a set of scrambled words and asked to make them form a sentence. Sentence construction was used in order to induce many of the same processes as sentence production, but without a generative component.

We predicted that since no generation was required in sentence construction, the normal age-related differences, which are observed in comparisons of explicit memory performance of young and old adults, would be observed. We also predicted that when directly comparing the sentence production and sentence construction, sentence production would result in significantly better memory performance for both age groups.

The results of Experiment 1 were as expected. Sentence production attenuated the differences normally observed in the explicit memory performance of young and old adults. The results of Experiment 2, on the other hand, were contrary to our expectations. While a small difference was observed in the memory performance of young and old adults, this difference was not significant. The results of the direct comparison between sentence production and sentence construction was as expected, with sentence production yielding significantly higher scores than sentence construction. No differences were found on the word-fragment completion tests.

The results of the present study support Craik's production deficiency hypothesis of age-related memory differences. They suggest that when the older adult is guided towards a more active, elaborative processing of target information, the differences normally observed between old and young adults can be attenuated.

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## INTRODUCTION

A widely recognized and readily identified hallmark of advancing age is difficulty in remembering. This memory loss can be manifested in many forms and varies in the degree of severity. It is generally accepted that memory decline as a natural consequence of aging involves both neurobiological and developmental changes in cognitive abilities. It is also agreed that the majority of these changes reflect alterations in the neurological functioning of the older adult. Assessment of age-related differences in young and old adults, as well as children, has been a major approach employed to explore these changes. The traditional approach has been to examine and compare differences from a systems viewpoint; e.g. sensory memory, short-term/long-term memory, explicit/implicit memory, and episodic/semantic memory. Exemplifying this approach is a summary table in a recent textbook of old/young comparisons on typical memory tasks (Haberlandt, 1999, p.207; see table 1), the majority of studies showing memory declines with aging, a few showing no differences in memory performance, and even fewer showing some advantages with aging.

This table provides a helpful overview of task-related age differences. At the same time, such an approach might yield overgeneralizations, thereby obscuring potential insights into the details of the nature of age differences

Table 1: Performance on memory tasks in younger and older people

**MEMORY DECLINES**

*Conventional Laboratory Tests*

Free recall  
 Cued recall  
 Recognition  
 Sentence and prose memory  
 Digit Span, letter span, word span

*Ecological Situations and Neuropsychological Tests*

Medicine labels  
 Activities performed  
 Names and faces for people  
 Songs on TV programs they have watched  
 Layouts of museums they have visited  
 Buildings located on familiar streets  
 Appearance of common objects, i.e. coins  
 Fewer flashbulb memories (Schacter, 1996)  
 Acquisition of new skills, i.e. word processing

*Contextual Information*

Context surrounding significant national events  
 Memory for whether information was heard or seen  
 Memory for upper or lowercase letters  
 Memory for whether information was read by either a man or a woman  
 Color in which information was presented  
 Memory for whether they saw a word or generated it  
 Memory for membership of word in most recent or earlier list  
 Memory for whether they learned an item recently or knew it before the experiment  
 Memory for whether an act was already carried out  
 Memory for which two orienting tasks they used at encoding  
 Spatial Memory  
 Temporal Memory  
 Susceptibility to misleading information presented after witnessing an event

*Speed Deficits*

Rate of rehearsal  
 Rate of scanning in memory search task  
 Rate of responding in short-term and long-term memory tasks

**NO DIFFERENCES**

Implicit memory tasks  
 Metamemory  
 Maintenance of previously acquired skills

**AGE ADVANTAGES**

Longer lasting sensory memory  
 Vocabulary scores  
 Remote memories from childhood  
 Anticipation in expert typists, athletes and professionals

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in memory performance. For example, without further analysis, the finding that older persons show poor memory performance on explicit tasks might be taken to define memory impairment in older adults. A concern is that even though this generalization may hold true in most instances, it might prove to be contingent upon details of experimental design and/or paradigm.

An alternative strategy (as suggested by Greenwald, Pratkanis, Leippe, & Baumgarner, 1986) is to ask whether the young/old differences hold true under all conditions or, whether alterations in experimental conditions might be devised that would modify or erase the age effect; in other words, to ask whether older persons perform more poorly than younger persons at all times and under all conditions. If there are some experimentally manipulated changes that produce different outcomes (viz., minimizing or erasing young/old differences), some of the bases for the original difference ought to be made apparent, possibly leading to a greater understanding of the nature and complexities of the age differences.

The major focus of this study is the examination of how changes in processing conditions might influence age differences in memory performance. The change in condition undertaken in this study is from the standard level of processing task to a form of processing called sentence production. The latter task was adopted because it requires more extensive cognitive activity than

does the levels of processing task. The introduction of more elaborative processing as a means of enhancing the memory performance of older adults has been recommended by Craik (1984). This view about young-old differences in memory performance has come to be known as the production deficiency hypothesis (Craik, 1984; Craik & Jennings, 1992).

Craik proposes that memory be understood in terms of encoding processes, retrieval processes, and the interactions of the two. He suggests that subsequent memory of a stimulus will reflect the analyses emphasized at encoding; e.g., good memory, representation follows distinctive encoding of an event that is meaningful in terms of past experience. Distinctive encoding processes require extensive attention and processing abilities which older people tend not to exhibit unless they are guided to do so. In essence, according to Craik's hypothesis, some of the decrements found in the memory performance of older adults relative to younger adults are the result of ineffective processing. An important inference from this suggestion is that some of these differences might be overcome in the older adult if the task and environment were to be structured to induce more efficient processing. While there is substantial support in the literature for this idea, the evidence is far from conclusive. Some studies do show more supportive conditions to benefit older adults (Backman & Nilsson, 1984, 1985), others demonstrate equal

benefits for young and old (Arbuckle, Vanderleek, Harsany, & Lapidus, 1990); Backman & Mantyla, 1988; Puglisi & Park, 1987), whereas still others show an advantage to the younger adults (Jacoby & Dallas, 1981). Such conflicting data indicate that the broad generalization that increased structure in the environment produces a greater benefit to the memory performance of the older adult is not adequate.

Craik and Jennings (1992) have outlined a number of possible explanations for these conflicting data. For example, if a task leads to better encoding of material, but only with the expenditure of additional resources, it may be that younger adults benefit more than older ones. An example of such a condition would be the addition of intentional learning instructions. It has been found that when participants are told a memory test will follow, the young outperform the old. In a study by Erber, Herman, and Botwinick (1980), recall was found to increase more for younger adults than for older adults when intentional learning instructions were added to the orienting task of checking whether certain letters were contained in the presented words. As more structure was provided to the participants by the provision of a semantic orienting task, further recall gains were approximately the same for both groups. It is likely that in the less structured condition, younger adults, but not the older ones, spontaneously engaged in more elaborate processing of the

materials, resulting in better recall. Thus, as suggested by Craik & Jennings (1992), not all changes that offer more support to younger subjects do the same for the older ones. One of the major goals of the present study was to attempt to further outline characteristics of tasks that offer particular benefit to the older adult.

The age-related cognitive change that was the major concern of this study was the nature of processing at encoding; and the two paradigms studied served to encourage different kinds of processing in younger and older adults. This research has made use of the task-comparison methodology suggested by Richardson-Klavehn & Bjork (1988). They state:

The underlying assumption of task-comparison methods is that different tasks make different informational demands on the subject. Based on patterns of dissociations and parallel effects across tasks as a function of critical independent variables, inferences can be made about the similarities and differences between mental states and processes necessary to comply with the informational demands of the respective tasks (p.477).

We compared two tasks with different processing requirements in order to reveal differences in the processing proclivities of younger and older adults.

Related to this point of view, Greenwald, Pratkanis, Leippe, & Baumgardner (1986) have suggested:

One method of avoiding needlessly over-generalized findings is to set out deliberately to reduce the generalizability of an existing finding. That is, one can seek to discover which, of the many conditions that were confounded together in procedures that have obtained the finding, are indeed necessary and sufficient. This is the method of condition seeking. (p.223).

The current study questioned whether young/old differences are universally present in explicit memory performance or whether there are specific conditions that might lead to equivalent old-young memory performance on an explicit memory test. We explored whether generation was a necessary condition to achieve this effect or whether elaboration without a generative component would suffice. In order to investigate these questions, we employed two tasks, sentence production and sentence construction.

In sentence production, the participant is instructed to generate a sentence with a target word as cue. In sentence construction, the person is asked to rearrange a set of scrambled words to form a sentence. It was our expectation that sentence production, which encourages the individual to a more elaborative, less constrained, encoding of the word than does the typical

levels of processing task, would benefit older adults more than younger ones. Hence, minimal difference in memory performance between the age groups was predicted on sentence production. Since previous studies have found that younger adults obtain consistently higher scores on explicit memory tasks than do older adults, the predicted finding of a reduced difference would suggest that the processing requirements of sentence production affected older and younger adults differently.

In sentence construction, asking the subject to rearrange scrambled words to form a sentence seems to induce similar processing as does sentence production but it lacks a generation component. In the absence of this generation requirement, we predicted a significant young/old difference. Furthermore, it was reasoned that directly comparing a generative to a nongenerative task would allow us to look at task differences as well as age differences induced by generation and elaboration without generation.

The theoretical formulation to be presented as a basis of this study is a cognitive-behavioral viewpoint of memory deficits in normal aging. Several additional views have contributed to the development of this study, and a brief survey of these follows.

### Theoretical viewpoints on the decline of memory in aging

In a review of the memory research on aging, Light (1991) characterized the several perspectives on the nature of memory decline in old age into four main categories: failures in metamemory, defective semantic encoding, failures of deliberate recollection, and diminished processing resources.

Metamemory is defined as one's knowledge about the characteristics of one's own memory and self-mediated use of memory enhancing strategies. Light suggests that differences in these abilities can have different effects on the memory performance of younger and older adults. An example of such an influence is that the older person may be more likely to use less efficient memory strategies or less likely to use task-appropriate strategies spontaneously. In addition, failures of metamemory can result in the older adult being less likely to monitor encoding and retrieval processes effectively. For example, Brigham & Pressley (1988) found that after exposure to two techniques (keyword/sentence generation), younger adults came to prefer a more effective keyword technique for learning low frequency words, while older adults did not.

Light also outlines old/young memory differences and similarities in the explicit/implicit memory systems as offering potential insight into the nature of

memory differences in these two populations. Explicit memory is defined as those that are explicitly available to conscious recollection, for example, facts, events, or specific stimuli (Squire, Shimamura, & Amaral, 1989). An example of an explicit memory task is a recognition test. On implicit memory tests, on the other hand, the individual is unaware that memory is being tested, for example, on a word-fragment completion task. A general finding in the literature is that on measures of explicit memory there is an age-related difference in performance favoring the young (Howard, 1988; Howard, Fry & Bruno, 1991; Light & Singh, 1987; Winocur, Moscovitch & Stuss, 1995; Grix, 1998) while on tests of implicit memory, there are no reported differences. Such findings lead to the suggestion that elements of explicit memory are at the source of the difficulties in memory abilities most often found in the older adult.

After a review of these hypotheses, Light (1988) concludes that they "... taken individually or collectively, do not provide an adequate account for the observed patterns of spared and impaired function found in old age" (p.366). Others have attempted to develop additional hypotheses about the nature of the changes in memory which accompany aging. One of these concentrates more on the role that the frontal lobes play in the memory process.

The frontal lobes in the memory process.

Historically, the hippocampal formation has been viewed as the anatomical substrate of memory. However, more recently, investigators have been focusing their attention on another area of the brain involved in the encoding and retrieval of memory, the frontal lobes. The frontal lobes are often described as being in charge of what are known as “executive functions”, for example, attention, planning, organization, set shifting, and problem solving. The current discussion will be limited to those functions of the frontal lobes related to deficits in the encoding and retrieval of information from memory.

Alexander Luria (1973) believed that the frontal lobes control planning and are involved whenever mental activity is not routine and requires initiation, maintenance, and monitoring of a plan. Many of his patients demonstrated memory problems, and he argued that these difficulties occurred because complex memory requires novel processing. An example of how such deficits can be explained by Luria’s approach was the performance of these patients on a simple list learning task. He found they tended to remember those words they could remember after the first presentation of the stimuli, but that they never actively sought to use mnemonic aids to improve their learning. It is this lack of spontaneous use of encoding strategies that is of most interest to the current

study, as this is the processing difference that Craik's production deficiency hypothesis suggests is responsible for some of the differences found between the memory performance of older and younger adults.

Signoret and Lhermitte (1976) attempted to demonstrate this deficit in a different way. They examined the performance of patients with frontal lesions on a paired-associate learning paradigm. In this paradigm, the participant is presented with pairs of words that have different degrees of association. For example, fruit – apple, are considered to have a strong association, while, chicken – mountain are considered to be weakly associated. Signoret & Lhermitte (1976) reported that patients with frontal lesions were very poor at learning the weakly associated word pairs. They also demonstrated that the deficit could be largely abolished when the patients were provided a strategy for learning the weak associates. They argued that this deficit occurred because in contrast to normal persons, patients with frontal lobe lesions do not use elaborative encoding strategies in a spontaneous way. It does appear, however, that they can use these strategies if they are provided. Thus, in this sense, the performance of patients with frontal lobe damage parallels that of the older person.

One of the difficulties of generalizing from such studies is the great difficulty in controlling for such variables as severity and location of the

lesion. There is some evidence that laterality of a lesion in the frontal lobe can have an effect on the type of memory deficit. For example, it has been suggested that bilateral frontal lobe lesions may cause more significant deficits than unilateral ones (Kolb & Whishaw, 1985). They found that patients with bilateral frontal lobe lesions demonstrated learning difficulties even with more closely related words, whereas patients with unilateral lesions did not demonstrate this effect. Presumably, the unilateral patients were still able to benefit from the use of an elaborative encoding strategy, which was found to be more efficient than a more passive rote learning one.

Other findings support the idea that differing degrees of impairment will occur with different severities of damage to the frontal lobes. Hirst (1985) examined metamemory deficits in patients with both bilateral and unilateral lesions; that is, deficits in the patient's knowledge or awareness of memory strengths and weaknesses. To examine metamemory, Hirst asked the patients questions about what would determine good or bad memory in different situations. An example of the type of question he asked was whether or not it would be easier to make a call immediately after hearing a telephone number or after getting a glass of water? He found that patients with bilateral lesions tended to give atypical answers to such questions, a finding consistent with

Luria's suggestion that patients with frontal lobe damage are impaired in the ability to monitor the effectiveness of one's plans.

Moscovitch and Winocur (1992) attempt to integrate such findings about the role of the frontal lobes in the memory process in this "Working with Memory" model. Their suggestion is that another function of the frontal lobes is as a cognitive mediation system in the encoding and retrieval of memories, and the semantic retrieval of words. According to the "working with memory" model, since conscious attention is involved in selecting and organizing the information to be encoded, these operations then serve as retrieval cues. Since the frontal lobes are believed to be involved in organization and planning functions, Moscovitch and Winocur suggest that this "working with memory" system is mediated by this area, specifically the prefrontal region. Hence, age differences in the efficiency of this system may contribute to the age differences found in the memory performance of older and younger adults. Major features of the working with memory approach are the strategic and organizational processes required at encoding, which can have profound effects on how well information is remembered. It follows, then, that the deficits found in older adults should be greater on those tasks that require organizational factors than on those that do not, which is what has been found

( Craik, 1968; Craik & Masani, 1967). As Salthouse (1982) noted in his review of organizational factors involved in memory,

A reasonable conclusion with respect to aging and organizational processes in memory is that older adults engage less frequently, and perhaps less successfully, in the types of organization that facilitate memory performance. No one source of evidence is completely compelling, but the consistency with which age differences in organization are reported makes it quite likely that a real difference in organization exists. (p.137)

Beyond the effects of the memory process, another factor related to the observed memory deficits in older adults is the advantage of possessing prior knowledge (Gillund & Perlmutter, 1989). This pre-existing knowledge allows the subject to process the information more efficiently with less expenditure of energy. According to the production deficiency hypothesis (Craik, 1984), when fewer resources are needed to encode the information distinctively, the deficits in memory performance often found in older adults will be reduced. In order to reduce the differences in performance then, one must insure that the target information is encoded within a context that is meaningful to the individual. It is quite possible that when a context is not very elaborate or meaningful,

younger people spontaneously engage in activities to enhance the encoding of the information while older persons do not. It would seem self-evident however, that better performance would follow from the ability to provide the context in which the target word is encoded because it would be consistent with their prior knowledge. As was suggested by Craik & Jennings, (1992)

This logic can be extended to include well-learned schematic information as a further source of internal environmental support. That is, rich, meaningful, and distinctive encodings may be achieved either by presenting a richly detailed stimulus (picture) or by utilizing the subject's existing knowledge to enrich the stimulus. The second method of enriching the encoded representation is presumably the one tapped by levels of processing. Deep encodings are not achieved by the expenditure of more attentional resources, but by greater reliance on preexisting schematic knowledge. (p.67)

Craik & Jennings (1992) also point out that while older people do continue to use schematic information to support encoding and retrieval in the same way as younger people, they are less effective at doing so. They are at a disadvantage particularly when the information has little association with their

script or schema and requires more elaborative processing for integration into memory.

While these viewpoints are all indirectly related to the current study, those related specifically to the processing of information are more directly relevant. Two processing viewpoints, which are particularly relevant, are levels of processing and generative processing.

### Levels of Processing

The levels of processing framework emphasized encoding manipulations in the memory process in order to examine the effects of such manipulations on memory performance ( Craik & Lockhart, 1972). This article has had profound effects on the investigation of the memory process as it instigated a great deal of research emphasizing the cognitive aspects of memory as opposed to the various systems of memory. In this conceptualization, acquisition of information is understood in terms of qualitatively different types of encoding processes, or depths (levels), with the basic tenet that deeper processing leads to better memory performance.

In a standard levels of processing paradigm, levels are operationally defined by the nature of the questions to which the subject must respond. A shallow level of processing is often induced by a “perceptual” orienting question, for example, a question about the surface features of the word (e.g.,

“Is the word printed in capital letters?”). In contrast, a deeper level is induced by asking questions that require semantic analysis and concentration on meaning (e.g., “Does the word refer to something that is alive?”). The levels of processing effect is demonstrated when memory scores are higher for semantically than nonsemantically encoded words

As mentioned earlier, a frequently reported finding in the memory and aging literature is that when typical semantic and nonsemantic orienting questions are used, younger adults perform significantly better than older ones on explicit tests, while no age difference is found on implicit tests (Howard, 1988; Howard, Fry & Bruno, 1991; Light & Singh, 1987; Winocur, Moscovitch & Stuss, 1995; Grix, 1998). Grix (1998) compared two groups, a younger (ages 18-35 yrs.) and an older group (ages 70-89 yrs.) making nonsemantic and semantic judgements about single words. She found, consistent with the previous levels of processing literature, that the younger group had higher recognition scores. In addition, recognition performance was higher for both age groups in the semantic processing condition than in the nonsemantic one. On the implicit task, on the other hand, no significant differences were found between the age groups.

Although the literature has reported robust differences between these two types of processing, there are a number of criticisms of the levels of

processing framework. A major one is the circularity of the idea of depth of processing as well as the inability to develop an independent measure by which to specify depth of processing (Baddeley, 1978). Furthermore, measurement of qualitatively different levels of processing in the semantic and nonsemantic domains has not been clearly outlined, and while it is clear that there are different types of semantic processing, measuring these presents great difficulty.

In an attempt to delineate the various levels of the semantic realm, Klein and Saltz (1976) introduced the idea of “levels of activation”. One of the major questions asked in their study was; “Is the deep semantic level activated in an all-or- none fashion, or are there levels within the semantic level?” (p. 671). According to their conceptualization of the semantic cognitive space, concepts that are specified on very few dimensions or that occupy a large region of space on a number of dimensions, are subject to a great deal of interference and rapid forgetting.

According to this model, a study task specifying the attributes of a concept represented by a meaningful stimulus will improve memory because such specification limits the amount of cognitive space occupied by the concept. Hence Klein and Saltz state “Deeper levels of processing involve the placement of the concept named by the word on more relevant dimensions,

leading to more precise specification of the concept region. Thus, deeper processing involves specification or activation of more relevant attributes of a meaningful stimulus, increasing its likelihood of being recalled” (p. 673).

Klein and Saltz (1976) employed the task-comparison method to compare different encoding tasks and their effect on memory performance. They varied the number of relevant dimensions of a stimulus activated by developing pairs of orienting tasks involving correlated and uncorrelated attributes of different words. Their expectation was that uncorrelated attributes would result in activation of a more precisely specified region of space than correlated ones whose specifications are more redundant, and thus, result in better recall. Examples of two highly related dimensions are happy-sad and pleasant-unpleasant, while examples of two moderately related dimensions are pleasant-unpleasant and fast-slow. Their findings supported their model, with greater specificity of semantic processing leading to better recall in incidental learning tasks. As a result, they suggested that meaning is not activated in an all or none fashion, but rather, in different levels.

### Generation as processing

A form of processing that is quite different from that used in the levels of processing paradigm is word generation, in which the individual is instructed to generate a word in response to a particular cue when given a rule,

for example, an opposite (e.g. black - white). A robust finding in the literature is the memorial advantage of self-generated target words over those that are simply read, an effect referred to as the generation effect (Slamecka & Graf, 1978). This generation effect has been found with a number of different kinds of cues including related word pairs, meaningful sentences, anomalous sentences, elaborators of partial sentences, and, recently, whole sentences. It should be noted that while both the generation and the levels of processing effects have been shown to be robust by the older literature, a direct empirical comparison had not been made before Grix (1998).

A number of different explanations have been offered for the generation effect. Among these are selective displaced rehearsal, the lexical activation hypothesis, and the fact that generation induces increased activation and arousal at encoding.

The selective displaced rehearsal hypothesis (Slamecka & Katsaiti, 1987) proposes that the generation effect is actually an artifact of the experimental design. Specifically, the generation effect is believed to occur only with a mixed list, for example, when subjects are required to both read and generate words within the same experimental task. According to this explanation, this design causes generation trials to garner more of the subject's attention at the expense of the read trials. A number of studies, however have

found generation effects in between-subjects designs (Crutcher & Healy, 1989; Fiedler, Lachnit, Fay, & Krug 1992).

Many researchers suggest that the generation effect stems from the richness of the associative links resulting from the generation process, an explanation sometimes referred to as the “lexical activation hypothesis” (e.g. Gardiner & Hampton, 1985). According to this view, the search of semantic memory resulting from generation activates semantic features related to the target which later serve as retrieval cues to access the generated word. Thus, the effects are not due to generation per se, but rather to the activation of related semantic features resulting from generation. A related finding is that while normal older adults do benefit from the generation effect (McFarland, Warren, & Crockard, 1985; Mitchell, Hunt, & Schmitt, 1986), dementia patients do not, (Mitchell, Hunt, & Schmitt, 1986), presumably because of deterioration of semantic memory in this population.

Another suggestion is that the generation process results in increased arousal (Jacoby, 1978) or increased cognitive effort (Griffith, 1976; McFarland, Frey, & Rhodes, 1980). A key idea underlying this explanation is that there are cognitive resources mobilized by generation that are not drawn upon for more passive tasks. Thus, the assumption is that instead of taking resources from another task, as suggested by selective displaced rehearsal,

generation draws on unused resources in the individual, resulting in increased cognitive effort. A consistent suggestion throughout these explanations is that generation appears to enable a more extensive and elaborate encoding process, and it has even been suggested that this “general encoding factor” underlies the main effect of generation (Glisky & Rabinowitz, 1985).

An attempt to factor out some of the critical features of the generation effect reported by Fiedler, Lachnit, Fay, and Krug (1992) eliminated the read versus generate conditions by making all tasks generative in nature and manipulating the degree of generation by varying the amount of semantic cueing provided. The groups in this study were composed of college student volunteers. Their finding was that as the amount of semantic cueing increased, memory scores decreased, presumably because of the decreased generation by the subject. They found such an effect in between-subject designs as well, arguing against the selective displaced rehearsal explanation of the generation effect. They proposed that the findings were a result of a gain of cognitive resources as a result of the increased amount of generation required with less semantic cueing.

This study suggests that subjects who generate more of the response will show a greater generation effect. Other studies have also suggested that the induction of additional cognitive resources is the mechanism underlying the

generation effect (Crutcher & Healy, 1989). It is important to note that Crutcher & Healy (1989) used a multiplication paradigm and still obtained a generation effect, showing that semantic activation is not the only basis for the generation effect.

The role of encoding processes in reducing old/young memory performance differences.

A major aim of the current study was to explore the aspects of encoding processes with potential to improve memory performance, in particular those encoding conditions that might result in an attenuation of the old/young differences in explicit memory performance. To date, a few studies have been conducted utilizing generation in examining age-related differences in memory and a closer look at these and some other relevant nongenerative studies follows.

McFarland (1983) found that children as young as seven years old demonstrated the generation effect, leading him to conclude that generation would be an appropriate paradigm for older adults, who might also have a “production deficiency”. McFarland, Warren, and Crockhard (1985) conducted a study comparing the memory performance of older and younger adults in a multi-trial task requiring them to generate or study synonyms or rhymes of stimulus words. They found both older and younger adults did better

on the generation than on the study condition although the older adults did not show a similar benefit on free recall until later trials.

Mitchell, Hunt, and Schmitt (1986) investigated the generation effect in young (mean age = 21.6 years), normal old (mean age = 65.6 years), and demented (mean age = 65.1 years) patients on both cued recall and source judgement tasks. They compared a task in which a whole sentence was presented to one in which an object name had to be generated to complete the sentence (e.g. The gentleman opened the \_\_\_\_\_). They found a substantial generation effect for the old and young adults although the comparison between the two was constrained by a ceiling effect in the young. In addition, they found that dementia patients did not benefit from the generation task. An interesting question raised by the authors of this study was: does the absence of the generation effect in a normal older person have diagnostic significance in terms of detecting an early dementia process?

The idea that generation induced elaboration may have different effects in younger and older adults was explored in a study of the effect of having each participant generate his or her own elaborators. Hashtroudi, Parker, Luis, and Reisen (1989), hypothesized that, according to the production deficiency hypothesis, older adults (mean age = 65.8 years) should benefit more than younger ones (mean age = 27.3 years) from such an encoding task. They

manipulated the level of elaboration by using three elaborative tasks as well as a generation task. The no elaboration condition presented base sentences (e.g. The tall man bought the crackers). The precise elaboration condition presented the base sentence along with a short phrase clarifying the relevance of the target word, which was an adjective (tall) in the base sentence (e.g., The tall man bought the crackers that were on the top shelf). The imprecise elaboration condition presented a base sentence and a short phrase that was related to the sentence, although it did not clarify the relevance of the target word (e.g., The tall man bought the crackers and left through the narrow passage). In the self-generation task, base sentences were presented and the participants were asked to write a short phrase that was a meaningful continuation for each base sentence.

In this study, Hashtroudi, et al (1989) found different patterns of results for younger and older adults. For the older adults, performance in the precise and imprecise conditions was close to the baseline while the self-generated elaborators improved performance significantly. For the younger subjects, on the other hand, precise elaborators and self generated elaborators, significantly improved recall to the same extent, while imprecise ones reduced it. It was noted that as a result of generating their own elaborators, the performance of the older adults more closely resembled that of the younger group. Hashtroudi,

et al suggested that the difference in their findings from others using similar tasks (e.g. Rankin & Collins, 1986) was that their task was less constrained. In the Rankin and Collins study, participants were given base sentences ending with “because” or “and” and, generation of a completion for the sentence resulted in an increase in the age difference in memory performance.

Hashtroudi, et al (1989) claim their approach led to active involvement of older persons in the learning process which is needed for them to take advantage of subtle meaningful relationships among the to be remembered material and is also needed to induce them to use their cognitive resources. A similar study, which used explanatory elaboration at both study and retrieval, but not generation, found no age differences between younger and older adults in recall (Cherry, Park, Frieske, & Rowley, 1993). It is clear that elaboration is one important aspect of the encoding process with potential to attenuate age-related differences in memory performance and that elaboration can take two forms, generative and nongenerative.

Another study of interest examined the effect of generation on the judgment of origin (i.e. source memory) in older (mean age = 68.2 years) and younger adults (mean age = 18.5 years) (Rabinowitz, 1989). Generation effects were found in both old and young, but the source memory scores for the old were consistently less accurate than for the young. In the first experiment of

this study, both older and younger adults were asked either to read words or to fill in two missing letters of a word and then were tested on a recognition task. Rabinowitz found that while the older adults obtained higher scores for generated rather than for read words, their performance did not approach that of the younger ones. In Experiment 2, the participants were required to generate category instances in the presence of category labels. Once again, he found a larger generation effect for the older adults relative to the younger adults. However, while recognition scores on the generation task were similar for both groups, a ceiling effect for the young constrained conclusions about age differences. It was clear however, that the older adults benefited from the generation task, and Rabinowitz suggested that this benefit was the result of a more elaborate or distinctive processing of the target words.

Additional evidence in support of the suggestion that a more elaborate and richer encoding mechanism could reduce the age-related deficits often found in memory tasks receives support from the work of Backman and his colleagues, who have been investigating memory functioning in normal adults, normal elderly and Alzheimer's patients. Their paradigm included the use of Subject Performed Tasks (SPTs), in which the subject is instructed to perform a series of simple, concrete motor actions for purposes of later recall. It was demonstrated that normal older adults performed as well as younger adults on

free recall of SPTs despite large differences favoring the young in various verbal control tasks. For instance (Backman & Nilsson, 1984, 1985), two groups of healthy older adults (73 and 82 year olds) and three groups of dementia patients (mild, moderate, and severely demented), were compared on both free and cued recall of SPTs or verbally presented sentences depicting the same verbal information as the SPTs. All groups performed better on SPTs than on the verbal tasks, and, for all groups, cueing effects were greater in the SPTs than in the verbal task (Karlsson, Backman, Herlitz, Nilsson, Winblad, & Osterlind, 1989). Karlsson suggested that the execution of simple motor acts depends on relatively well-preserved motor schemes, and, thus, encoding in this form may help control processing and focus attention. In his discussion of the Karlsson, et al (1989) study, Backman (1997) suggests that the use of over learned motor programs provided by the SPTs leads to a richer encoding process, perhaps activating information in semantic memory, resulting in better memory.

The work of Backman and his colleagues suggests that a variety of elaborative encoding tasks, even those that do not require a great deal of cognitive resources, can enhance memory performance in both normal older and demented populations. They suggest that there is an age-related increase in the level of support needed to optimize memory performance in older adults.

Hence, tasks in which instructions, retrieval conditions, or materials themselves guide the learner in initiating appropriate cognitive operations help older adults utilize their cognitive reserve capacity to reduce, or even eliminate, age differences in memory. An underlying assumption of this suggestion appears to be that older people do not spontaneously use such strategies, but when they are provided, their performance improves.

Recent studies from this laboratory have focused on the effects of various generation tasks on recall performance. Particularly relevant to this discussion is sentence production, introduced in an experiment examining age differences and processing paradigms (Grix, 1998). In the first experiment of this study, a typical levels of processing difference between younger and older adults was found where the younger adults performed significantly better than the older ones on a recognition memory test.

Grix's second experiment used sentence production, which was designed to evoke more active, elaborative semantic encoding. A nonsemantic task was also used, where the participants were shown a word, told to read it, then to generate five words beginning with the same letter. Since the subjects were unaware that a memory test would follow, there was no reason to believe they would attend to the meaning of the word. Rather, it was assumed that attention would be directed to the perceptual aspects of the word, mainly the

first letter. This task served as a control condition, because generation was present without semantic activation.

In her study, Grix (1998) found that both age groups benefited from the introduction of sentence production. Grix (1998) also found that older adults performed at a level equivalent to younger ones. This conclusion, however, was tempered by the presence of a ceiling effect in the young group.

A series of studies by Graf (1980; 1981; 1982) compared two different forms of processing sentences to simply reading them. The two experimental tasks were generate and transformed sentences. In the generate task, subjects were presented with four common nouns and were given a grammatical structure out of which they could organize the words and form a sentence. Graf suggested that this task was a generation task, a classification other authors have questioned (e.g. Glisky & Rabinowitz, 1985). In the second task, the participant was presented the sentence in an upside down orientation and asked to read it. As an additional variable, Graf (1982) used meaningful and anomalous sentences within these two processing conditions. An example of a meaningful sentence is "The tiny mouse frightened the cook". An example of an anomalous sentence is "The cheerful carpet exchanged the mouse". The same sentences were used in both experiments.

In Graf (1982) , both generated and rotated sentences were found to yield better recognition than were sentences that were read (control condition), and the advantage was enhanced with the meaningful as compared to the anomalous sentences. Although no direct statistical comparison was undertaken, word recognition scores for both the generation and transformed sentences were judged to be similar, with the transformed sentences maintaining a small advantage (Generated = 80.99, Transformed = 86.63). Graf concluded that it was not generation itself that resulted in the better memory performance but the operations induced by the task, which were also induced by the rotated sentences. He suggested that included in these operations was extensive analysis of each word as well as of the relationships among the words. These analyses were made additionally meaningful, presumably by semantic activation. He also proposed that by focusing more attention on each word there is a greater chance of developing an integrated trace of its features and greater attentiveness to the individual words of the sentence led to greater elaboration of them.

### Rationale of the Present Experiments

The experiments in this study compared the performances of older and younger persons on both sentence production and sentence construction. The first experiment utilized two generative tasks, one semantic (sentence

production) and one nonsemantic, in which the participant was asked to generate five words beginning with the first letter of the cue word (see Grix, 1998). While word generation has been viewed as an appropriate paradigm for studying age effects in memory performance (McFarland, Warren, & Crockard, 1985; Rabinowitz, 1989; Crockard-Brown, Niinikoski, & Warren-Duke, 1993), the attributes of sentence production suggested it would provide greater benefit than generation tasks used in previous studies.

Most studies of generation and most references to the “generation effect” require that the target word be generated from either a related word or an incomplete sentence. In these tasks, the participant generates only one word and often (as with synonyms, antonyms, etc.) that word is generated effortlessly. Sentence production has the advantage of having no constraint on the amount and the context of the material to be generated. In the sentence production paradigm, however, the target serves as a cue and the person provides the whole sentence and hence, the context in which the cue is remembered. This type of generation also requires much greater analysis than word generation, for example, requiring the participant to take into consideration grammar and structure, as well as meaningfulness. In addition, since the meaning of the sentence is provided by the participant, it is likely this type of processing leads to greater semantic activation, including sentences that

have more meaning to the individual than one that is provided to him/her. Craik (1984) said that one aspect of a good trace is that it must be meaningful in terms of past experience. Thus, it is suggested that sentence production incorporates aspects of the encoding event not yet examined in conjunction with the generation effect in the literature, having the subject provide the context in the encoding event. Furthermore, this task allows each person an individual elaboration of the word, also an important aspect of forming a better memory.

Sentence production involves more “self-referencing” than other generation tasks found in the literature. Self-referencing has been identified as a “deep” form of processing (Rogers, Kuiper, & Kirker, 1977), giving it relevance to the current discussion. In addition, it has been suggested that effort-minimizing strategies may be utilized when processing familiar information (Forgas, 1992), a fact which would appear to give an added benefit to older people.

Thus, sentence production appears to contain many of the elements necessary for inducing effective encoding for the older adult. One helpful aspect of this task is the fact that subjects appear to be able to complete it quite effortlessly. In addition, the context in which the words are encoded is likely to be meaningful to the subject, because it is chosen by him or her. Another

advantage is that the individual's attention is focused because they become truly active participants in the process while elaboration of the stimulus is built in to the encoding condition. In a sense then, we have a highly active task producing deep encoding while requiring the expenditure of relatively little effort. Hence, we predicted that sentence production would lead to equivalent scores between older and younger adults on a recognition memory test. No differences were predicted on the word-fragment completion test.

The second experiment evaluated the generative component described earlier. It included both a semantic and nonsemantic, nongenerative task. The nonsemantic task used required the individual to count the number of letters in each word of a scrambled set of words. The directions emphasized the fact that the task was timed and thus, it is reasonable to assume the participant concentrated on perceiving and calculating the number of letters, and not on the semantic aspects of the word. The semantic task of this experiment was the previously described sentence construction.

Our decision to use sentence construction as our nongenerative task was heavily influenced by Graf (1980; 1981; 1982). The operations induced by the unscrambling task in Graf's studies were similar to those we believed were beneficial in sentence production. We question along with others, the classification of this task as a generation task (Glisky & Rabinowitz, 1985). In

any event, it is a qualitatively different task from sentence production. Hence, we used this modified form of Graf's unscrambling task in our nongenerative task to induce the same type of processing as that of sentence production, while eliminating generation.

The second experiment of the present study maintained the semantic and nonsemantic distinction between conditions while eliminating the generative aspect of the tasks. It also presented the material in sentence form and presented the subject with more active, elaborative encoding of the information than does the typical levels of processing task. It was however, more constrained than sentence production, with all the words presented to the subject, who simply had to rearrange them. The subjects did not provide the context in which the information was encoded as the words were already embedded in sentences. Thus, sentence construction required the participant to use the semantic features of the words as well as the semantic framework provided by the given sentence structure.

We predicted that the performance of the two age groups on sentence construction would differ. We expected an old/young difference with the performance of the older group to be poorer than that of the younger one. No differences were predicted between the groups on the implicit memory test.

Finally, consistent with the task-comparison methodology (Richardson-Klavehn & Bjork, 1988), the current study allowed us to compare the paradigms themselves. Our prediction was that sentence generation would lead to a deeper, more elaborate level of processing in both younger and older adults, and thus, induce better test performance than would sentence construction.

In summary, we used two paradigms, differing in the presence or absence of generation, both involving sentences. At the same time, in both experiments, we maintained a semantic/nonsemantic distinction, allowing comparisons with the levels of processing paradigm. We hypothesized that semantic generative processing would benefit the explicit memory test performance of both younger and older adults but that it would benefit the older more than the younger adults. In addition, based on previous work in this laboratory (Grix, 1998), we expected sentence production to attenuate the difference normally observed between younger and older adults on explicit memory tasks. The underlying rationale for this last prediction was Craik's production deficiency hypothesis, that at least some of the differences normally observed in the memory performance of younger and older adults can be attributed to differences in the way the two groups process information at encoding. Craik had suggested that when the older adult is guided to a more

elaborate encoding of information, the differences in memory performance can be reduced.

In the second experiment we predicted that nongenerative sentence construction would not provide a differential benefit to older adults and, thus, the difference in memory performance typically found favoring the young would be present. Finally, we hypothesized that when directly comparing sentence production to sentence construction, sentence production would result in significantly better explicit memory test performance than would sentence construction, regardless of age.

### Experiment 1

Experiment 1 used sentence production as a form of generative processing. We predicted that the semantic task, which required the subjects to generate a sentence in response to a presented word, would lead to better encoding in both groups, and, minimize the age differences in explicit memory scores typically found in the literature. Thus, the requirement that a sentence be produced from a word was expected to result in better memory performance than what is usually found with standard levels of processing tasks for both groups, with a greater benefit for the older group. The nonsemantic condition of Experiment 1 required the participant to generate five words beginning with the first letter of the presented word. The use of this condition along with

sentence production, represents a departure from paradigms frequently found in the literature comparing a generative task with a read condition. This divergence from previous paradigms allowed us to compare two generation conditions, one a semantically based generation task and the other, a nonsemantically based one, in order to determine the advantage of semantic generation, if any.

### Method

Participants. Twenty-four 18 to 35 year old Queens College undergraduates, nine male and 15 female, participating as an option to fulfill a course requirement, comprised the younger group. Twenty-four 65-88 year-olds, eight male and 16 female, who were recruited from senior citizen centers in the Queens, New York area, made up the second group.

Each participant completed a background questionnaire and was selected based on the following inclusionary criteria: English as a primary language; age range of 18-35 for younger adults and 65-89 for older adults. Exclusionary criteria for both groups were a score below 25 on the Mini Mental State Examination (Folstein, Folstein, & McHugh, 1975) or a history of head trauma, epilepsy, or neurological disease. Approval for the study was obtained from the Queens College IRB and informed consent was obtained

from all participants in the study. Table 2 presents the demographic characteristics of the participants.

Apparatus & Materials. The target words consisted of 128 English words of 6 - 9 letters, of low, medium, or high frequency of occurrence, taken from Paivo, Yuille, & Madigan's (1968) ratings of 925 nouns. These words were arranged in two lists and were the same words used in Grix 's (1998) first experiment.

For the older adults, the experimental sessions were conducted at senior centers or, in a few cases, the participant's home in Queens. The experimental materials were presented on a Toshiba laptop computer. For the younger adults, the study was conducted on IBM personal computers in the laboratory. All computers were programmed identically to present all instructions and materials and to record all responses.

Experimental Design. There were three between group variables: two word lists; order of presentation of two blocked study conditions (semantic or nonsemantic task first, counterbalanced); and age groups (younger and older adults). List and Order were included to examine the compatibility of the word lists and the order in which the participants studied the to be remembered material. There were also two within group variables: processing condition (nonsemantic/semantic) and memory test (recognition/word fragment

Table 2:

## Demographic Information for Experiments 1 &amp; 2

Experiment 1				
	Younger Adults		Older Adults	
	<i>M= 9 F=15</i>		<i>M= 8 F=16</i>	
Variable	M	SD	M	SD
Age (years)	20.2	4.3	76.4	6.0
Education (years)	13.4	.98	13.9	3.8
Vocabulary (WAIS-III)	42.5	8.3	43.9	6.6
Digit Span (WAIS-III)	18.8	4.7	17.7	3.8
Experiment 2				
	Younger Adults		Older Adults	
	<i>M= 7 F=17</i>		<i>M= 4 F=20</i>	
Variable	M	SD	M	SD
Age (years)	26.1	4.8	76.6	6.9
Education (years)	14.7	1.6	13.1	2.5
Vocabulary (WAIS-III)	42	12.1	45.5	8.0
Digit Span (WAIS-III)	18.9	4.4	17.5	4.3

completion). As a result, there was a 2(list) x 2(order of presentation) x 2(age group) x 2 (processing task) mixed design.

Analysis of variance (ANOVA) was undertaken separately for word-fragment completion and recognition tests. The dependent measure was proportion of correct responses on each task. For recognition, baseline data were provided by the number of new words incorrectly identified as having been seen before. For word fragment completion, baseline data were the number of new word fragments for which target words were given.

Procedure. Participants were tested individually, with test duration of 1 - 1.5 hrs. Before testing began, the subject completed a background questionnaire and the MMSE was administered as a screening measure.

In sentence production, there were two sets of directions arranged in counter balanced blocks, semantic and nonsemantic presented before the study list. For the semantic task, the following instructions appeared on the computer screen: "For each of the following words, say a sentence aloud that includes the word." For nonsemantic generation, the following instructions appeared on the computer screen before the presentation of the study list: "For each of the following words, say five words that begin with the same letter as the word on the screen".

For the experiment itself, after the subject read the instructions, one of the two lists was presented, one word at a time, accompanied by blocked processing instructions. For all participants, the experimenter keyed in the subject's response so as to not put the older subjects at a disadvantage. For the study phase, two lists and 12 buffers, 6 at the beginning, and 6 at the end, were presented. The same 12 buffers were presented to all subjects but were not used in the memory test nor in the statistical analysis; they were used to control for primacy and recency effects.

Half of the words were preceded by the nonsemantic question and half, by the semantic one. Each word appeared equally often and randomly across subjects in each of the two study conditions. The two sets of questions were also counterbalanced across blocks of words in each of the lists, and order of block presentations was counterbalanced across subjects.

Upon completion of the study phase of the experiment, memory testing began. Half of the target words of list 1 and half of the target words from list 2 formed the recognition test while the remaining words formed the word-fragment completion test. If the subject did not respond in the allotted time, the next word appeared on the screen. All subjects were given the word fragment completion before the recognition portion of the test in order to

minimize the possibility that the subject would become aware that a memory test was involved.

The time for each word's presentation was to 5 s for study, 20 s for word fragment completion, and 10 s for recognition. For each of the blocks in the study tasks and for each of the tests, the words were presented in a different randomized order for each subject.

After completion of the experiment proper, the Vocabulary and Digit Span subtests of the Wechsler Adult Intelligence Scale, Third Edition (WAIS-III), were administered to all subjects in order to allow comparisons between groups in the areas of vocabulary and attention.

### Results-Experiment 1.

Table 3 and Figure 1 show mean scores for the baseline and two processing conditions for Experiment 1 for both age groups. These data show that in both the young and old groups, for the recognition test, the words in the semantic generation task were better remembered than those in the nonsemantic generation task. In addition, on the semantic generation task the means of the old and young groups were quite close. The word fragment completion test, on the other hand, showed no differences between the groups for semantic and nonsemantic generation. No age differences were found.

Table 3:

Mean Proportions of Correct Responses for Recognition and Word Fragment Completion- Experiment 1

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<i>Younger Adults</i>			
<i>Test</i>	<i>Baseline</i>	<i>Nonsemantic Semantic</i>	
<b>Recognition</b>			
M	.13	.47	.88
SD	.14	.22	.17
<b>Completion</b>			
M	.19	.31	.36
SD	.10	.12	.15

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<i>Older Adults</i>			
<i>Test</i>	<i>Baseline</i>	<i>Nonsemantic Semantic</i>	
<b>Recognition</b>			
M	.22	.42	.86
SD	.19	.28	.12
<b>Completion</b>			
M	.20	.32	.29
SD	.11	.15	.16

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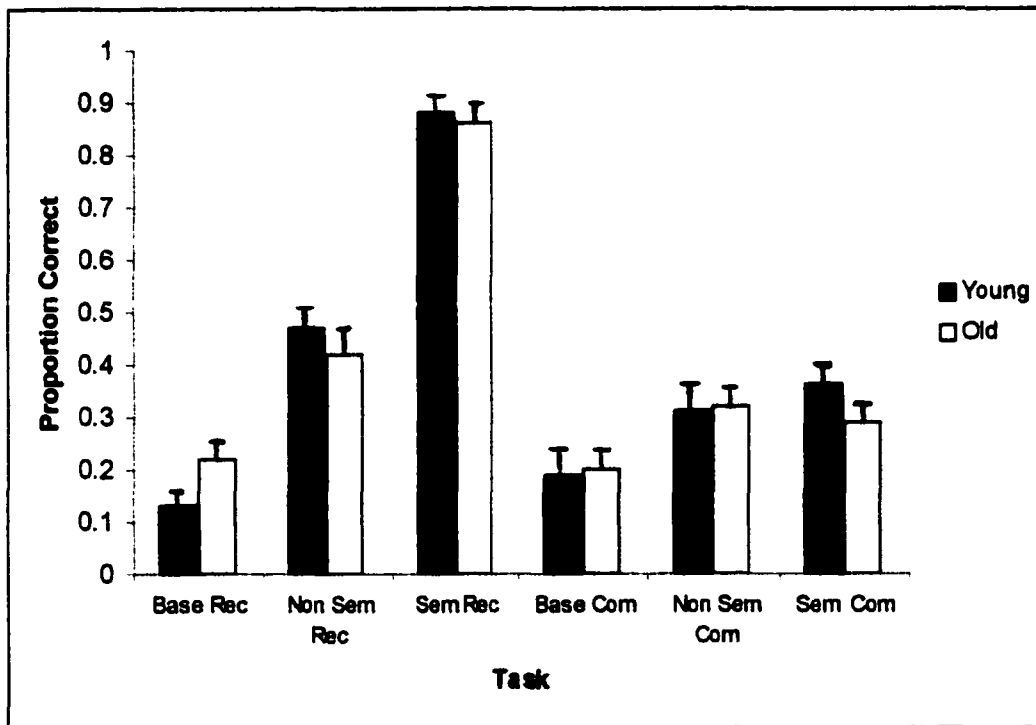


Figure 1: Mean proportions of correct responses for recognition and word fragment completion for Experiment 1

Mean proportions of correct responses for both the recognition and completion tests were analyzed by a Four-Way Mixed Model Analysis of Variance for each memory test. The three between-subjects factors were age group, word list, and order of study task. It was not expected that either word list or order of study task would be statistically significant. The within-subjects factor was the type of generation, either semantic or nonsemantic. The dependent variable was the proportion of correct responses on each task.

Recognition – Proportions Correct. There was no significant main effect for age group:  $F(1,40) = .26$ . In fact, young and old age groups achieved almost identical scores. There was a significant main effect for list:  $F(1,40) = 15.95$ ,  $p < .001$ . In addition, a significant interaction was found for list by age:  $F(1,40) = 8.81$ ,  $p < .01$ . This was completely unexpected, particularly since these lists were used by Grix in her first experiment, and no significant differences had been found. In addition, list was not significant in the analysis of the word fragment completion test. We were concerned that this difference could have accounted for the lack of observed differences between the groups, and thus, warranted further study.

The mean recognition score of list 1 (.73) was significantly higher than that of list 2 (.59). The older group performed better than the younger on list 1 (means of .79 and .69, respectively), while the younger group performed better

than the older one on list 2 (means of .65 and .52, respectively). Due to the fact that the lists were counterbalanced in terms of their presentation, the same proportion of younger and older adults received each list the same number of times. Thus, the lack of observed differences between the groups is not the result of the older group receiving the easier list more than the younger one. Hence, since no age selectivity could be detected favoring one group over the other, this list effect was dismissed as being of consequence to the lack of observed differences between the younger and older adults on the explicit memory test.

As expected, there was a significant main effect of type of processing  $F(1,40) = 122.96, p < .001$ , with semantic processing resulting in significantly higher proportions of correct responses than nonsemantic processing, for both age groups.

To summarize the findings, sentence production, a more active, elaborative form of encoding, attenuated the differences normally observed between older and younger adults on the explicit memory task. Hence, the introduction of a more extensive processing condition appears to eliminate differences in memory performance between younger and older adults on a recognition test by benefiting the old more than the young.

Word Fragment Completion-Proportions Correct. No significant main effects were found for either word list or order, and there were no significant interactions. In addition, there were no significant main effects for either group or processing condition, and no significant interactions. Furthermore, there were no significant differences between the two age groups in either the semantic or nonsemantic processing conditions.

Discussion.

In this study, sentence production was found to benefit older adults more than younger ones. Since a consistent finding in the literature is that older adults perform at a lower level than younger ones on explicit memory tasks (Light & Singh, 1987; Grix, 1998; see Howard, 1988; Light 1988, for reviews), the absence of differences between the scores of the two groups in this experiment suggests that the older adults benefited more than the younger ones. For explicit memory test performance, the greater processing requirement of sentence production, resulted in the older adults performing on a level equivalent to the younger ones. One can infer from this finding that this task has tapped some resources in the older adult not normally drawn on in typical levels of processing tasks.

In other respects, the results of Experiment 1 are also consistent with what is found in the levels of processing literature. Large differences between

the recognition memory scores on the nonsemantic and semantic processing task were obtained, with both young and old groups performing better on semantic processing than on the nonsemantic. These robust differences attest to the validity of this distinction across the two paradigms. It is important to note that both the semantic and nonsemantic tasks were generative in nature, and thus one cannot attribute these results to the difference between a more active (generation) task and a more passive one (reading). The effects on the word-fragment completion were quite different, with no age group differences and no difference between their semantic and nonsemantic recognition scores. These findings of no differences are also quite consistent with what is typically found in the levels of processing literature.

Although it is clear that involving older persons in a more active, elaborative task improves memory performance more than it does that of younger adults, it is not clear whether it is the process of generation per se, or some other form of elaboration which produces such improvement. While the studies in which similar results have been obtained employed a generative task (Mitchell, Hunt, & Smith, 1986; Hashtroudi, Parker, Luis, & Reisen, 1989; Rabinowitz, 1989), such effects have also been observed with nongenerative tasks (Cherry, Park, Frieske, & Rowley, 1993).

Cherry et al (1993) examined a number of different levels of elaboration. Using the Production Deficiency Hypothesis as their basis, they suggested the benefit provided by presenting the elaborations at both encoding and retrieval would be greater for the older adults (mean age = 67.9 years) than the younger ones (mean age = 19.2 years). They found that both older and younger adults benefited from explanatory elaborations at both encoding and retrieval. In these experiments, however, the younger adults performed significantly better than the older ones. In a further experiment they found that with a shorter list the performance of the two groups was not significantly different while larger differences remained under conditions of less encoding and retrieval support. Their suggestion was that a longer list increases the processing demands of the task, presenting a greater disadvantage to the older adults. They suggested that, for old and young, the nature of the stimuli used may determine whether elaboration at encoding alone is effective in increasing memory performance.

A question arising from the present experiment involves the issue of “activation of levels of meaning” (Klein & Saltz, 1976). Rather than comparing semantic and nonsemantic levels of processing, Klein & Saltz attempted to differentiate processing activities within the semantic realm, suggesting that meaning is not activated in an all or none fashion, but that there

is an activation of levels of meaning. They stated that, at that time, the issue of activation of levels of meaning was relatively unexplored. It seems that this statement still applies today and we attempted to integrate the idea of levels of meaning into the second experiment of this study.

### Experiment 2

In Experiment 2 we employed sentence construction, which also required the participant to be active in the learning process. While it also included both semantic and nonsemantic tasks, no generative activity was required. The main question we asked was whether findings of experiment 1 were a consequence of increased elaboration or of the generation process. Our view favored the contribution of generation as important in the attenuation of old-young differences in memory performance.

Sentence construction requires many of the same cognitive activities required by sentence production. However, the degree of elaboration was constrained in sentence construction compared to sentence production since the context was provided for the subject and they were not generating it themselves. We predicted that the above noted constraints would lead to lower scores than were obtained with sentence production on the recognition memory test for both age groups. We also predicted that this loss would be greater for the older adults than the younger ones and, as a result, the two groups would

display the differences normally observed on explicit memory tests. Thus, although the semantic task in the second experiment was still an active one, inducing elaboration of the target material, it would not enhance memory performance to the same degree as in Experiment 1.

In the nonsemantic, nongenerative task of Experiment 2, scrambled words appeared on the screen, and subjects were asked to count the number of letters in each word. Thus, we were able to keep the nonsemantic/semantic distinction intact between the two experiments, continuing to allow a meaningful comparison to the levels of processing literature.

### Method

Participants. Twenty-four 18 to 35 year old Queens College undergraduates, seven male and 17 female, participating as an option to fulfill a course requirement, comprised the younger group. Twenty-four 65-85 year-olds, four male and 20 female, recruited from senior citizen centers in the Queens, New York area, comprised the older group. Inclusionary and exclusionary criteria were the same as in Experiment 1. Approval for the study was obtained from the Queens College IRB and informed consent was obtained from all participants.

Materials. The same 128 words used as in the first experiment. These were put into simple sentences of 6-8 words. In an attempt to reduce the total

number of sentences that were presented to the subject, each sentence contained two target words, resulting in the formation of 64 sentences. An additional 6 buffer sentences were constructed from words not on the list. The words of the sentence were rearranged in a systematic order, according to the following formula: <verb> <article> <noun><noun><article><preposition>. An example of a sentence in the scrambled form is “went the children museum the to”.

Experimental Design. Both between and within group variables were the same as in Experiment 1. As a result, there was a 2(list) x 2(order of presentation) x 2(age group) x 2 (processing task) mixed design. Dependent measures and analyses were also the same as in Experiment 1.

Procedures. Participants were tested individually, and test duration was 1 - 1.5 hr. Before testing began, each subject completed a background questionnaire and the MMSE was administered as a screening measure. All procedures were the same as those in Experiment 1 except for the differences outlined below.

In the sentence construction paradigm, there were two sets of directions, semantic and nonsemantic. For the nonsemantic task, the following instructions appeared on the computer screen before the presentation of the study list: “For this task, a group of words will appear on the screen. Count the

number of letters in each word as quickly as you can. Say the correct number of letters in each word aloud as soon as you finish counting each word.” For the semantic task, the following instructions appeared on the computer screen: “In this task, a group of scrambled words will appear on the screen. Put them in order so they will form a correct sentence. Say the words aloud in the proper order”. For both conditions, the scrambled sentence remained on the screen until the task was completed; this, of course, opened up the possibility of unequal duration for the two conditions. The possibility of further processing of the material after the response was complete dictated our decision to terminate stimulus presentation at the completion of the response. A major consideration was the strong possibility that the younger persons would be more likely than the old to spontaneously engage in more extensive processing.

For memory testing, the duration of each word’s presentation was 20 s for word fragment completion, and 10 s for recognition. For each of the blocks in the study tasks and for each of the tests, the words were presented in a different randomized order for each subject.

### Results-Experiment 2.

Table 4 and Figure 2 show mean scores for the baseline and the two processing conditions in Experiment 2. These scores were lower for all conditions compared to those of Experiment 1. These data show that, in both age groups,

for the recognition test, the words in the semantic task were better remembered than those in the nonsemantic task. A difference in the recognition scores of the younger and older group was not statistically significant. On the word fragment completion test, no differences were found in either group between the semantic and nonsemantic tasks.

Mean proportions of correct responses for both the recognition and completion tests were analyzed by a Four Way Mixed Model Analysis of Variance for each memory test. The three between-subjects factors were age group, word list, and order of study task. The within - subjects factor was the type of processing, semantic or nonsemantic. The dependent variable was the proportion of correct responses on each task.

Recognition-Proportions Correct. There was no significant main effect for age:  $F(1,40) = .79$ . There was a significant main effect for type of processing:  $F(1,40) = 56.80, p < .001$ , with the semantic processing task resulting in significantly higher proportions correct than the nonsemantic processing

Table 4:

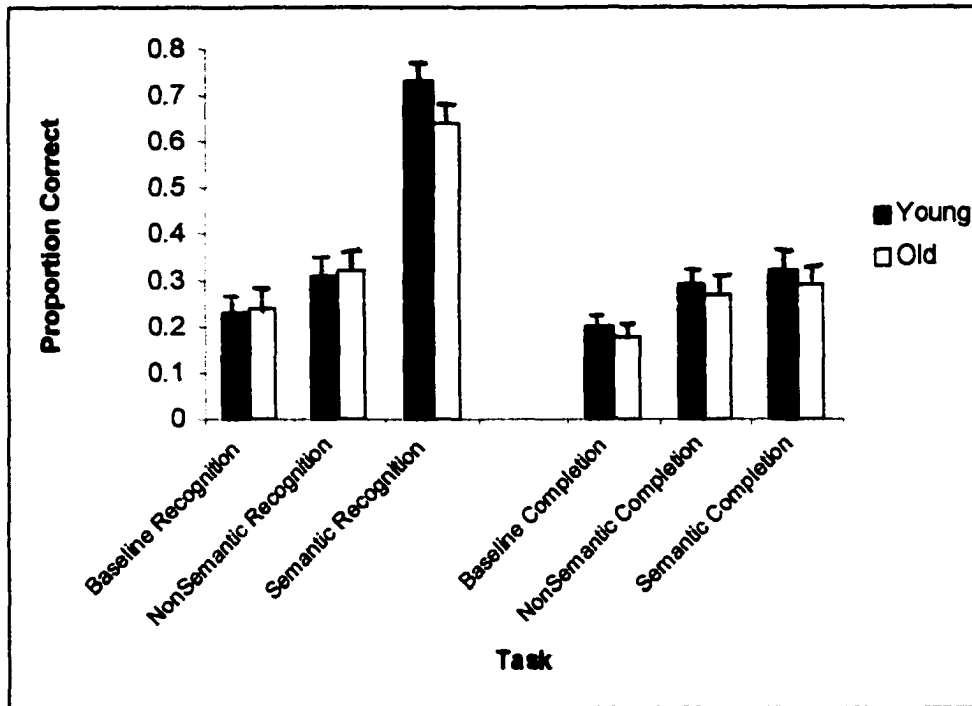
Mean Proportions of Correct Responses for Recognition and Word Fragment  
Completion in Younger and Older adults-Experiment 2

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<i>Test</i>	<i>Baseline</i>	<u><i>Younger Adults</i></u>		
		<i>NonSemantic</i>	<i>Semantic</i>	
<b>Recognition</b>				
M	.23	.31	.73	
SD	.17	.21	.19	
<b>Completion</b>				
M	.20	.29	.32	
SD	.09	.11	.15	

---

	<i>Baseline</i>	<u><i>Older adults</i></u>		
		<i>NonSemantic</i>	<i>Semantic</i>	
<b>Recognition</b>				
M	.24	.32	.64	
SD	.23	.25	.26	
<b>Completion</b>				
M	.18	.27	.29	
SD	.09	.15	.16	



**Figure 2:** Mean proportions of correct responses for recognition and word fragment completion for Experiment 2

condition. There were no significant interactions between age and processing conditions.

Thus, while overall performance of both groups decreased with the introduction of an active, elaborative task without a generative component, there was still not a significant difference in the memory performance of younger and older adults on a recognition test.

Word Fragment Completion-Proportions Correct. A significant main effect was found for word list E ( $F(1,40) = 6.27, p < .01$ ). This finding was unexpected, particularly since no evidence of a difference was found for the same lists in the recognition test analysis. In addition, there were no significant differences between the two age groups in either the semantic or nonsemantic processing conditions.

Comparison of Sentence Production and Sentence Construction:

A major goal of this study was to compare the effects of different encoding processes on explicit memory test performance with age as the critical variable. A between experiment comparison was carried out on the recognition scores. Table 5 shows the mean scores for the baseline and two processing conditions for the recognition scores of both age groups. Figure 3 is a bar graph of these data which show that the recognition scores for both

Table 5:

## Mean Proportions of Correct Responses for Recognition Test-Experiments 1 &amp; 2

---

Young adults			
Experiment 1	<i>Baseline</i>	<i>NonSemantic</i>	<i>Semantic</i>
M	.13	.47	.88
SD	.14	.22	.17
Experiment 2	<i>Baseline</i>	<i>NonSemantic</i>	<i>Semantic</i>
M	.23	.31	.73
SD	.17	.21	.19

---

Older Adults			
Experiment 1	<i>Baseline</i>	<i>NonSemantic</i>	<i>Semantic</i>
M	.22	.42	.86
SD	.19	.28	.12
Experiment 2	<i>Baseline</i>	<i>NonSemantic</i>	<i>Semantic</i>
M	.24	.32	.64
SD	.23	.25	.26

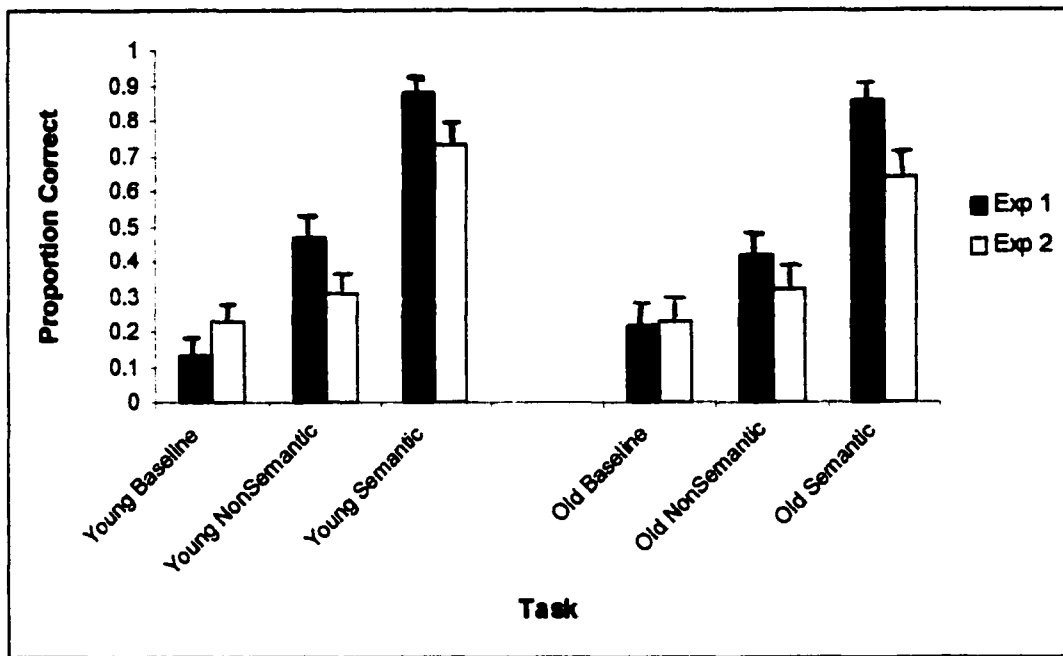


Figure 3: Mean Proportions of Correct Responses for Recognition Test-Experiments 1 & 2

groups were higher in the generation task (Experiment 1) than in the nongeneration task (Experiment 2).

Mean proportions correct responses were analyzed by a Three Way Mixed Analysis of Variance for the recognition tests, with Group (Old/Young), Processing Condition (Semantic/Nonsemantic) and Paradigm (Generation and Nongeneration) as the three factors. We did not expect a statistically significant difference in age group, while processing condition and task were expected to reach significance.

A significant main effect was found for task  $F(1, 95) = 26.96, < .01$ , with sentence production resulting in significantly higher scores than sentence construction. In addition, a significant effect was found for processing condition  $F(1, 95) = 160.211, < .01$  with semantic processing resulting in significantly higher scores than nonsemantic processing. No other main effects or interactions were statistically significant.

### Discussion.

Experiment 2 employed semantic and nonsemantic tasks without a generative component. These tasks were designed to allow comparison with the generative semantic and nonsemantic tasks used in Experiment 1, in order to examine the contribution of generation to the results of Experiment 1. We predicted that the generation task would result in better performance than the

nongenerative task in both age groups. We also expected that the nongenerative tasks would result in poorer performance by both groups in comparison to their performance in Experiment 1, and, this reduction would be greater in the older adults than in the younger ones. The current results only partially support these expectations.

As expected, the semantic task produced higher scores than the nonsemantic one for both age groups. Contrary to expectations, however, the nongenerative task differentially affected the scores of the older group, as the age group differences in recognition scores were not significant in the second experiment. Thus, contrary to the usual differences found between older and younger adults on explicit memory tests, we found the two groups to be performing at an equivalent level. This finding was contrary to our expectation that using a nongenerative task the older adults would perform more poorly than the younger adults. Hence, generation is not the only way to provide an advantage to older adults, as sentence construction had an effect similar to that of sentence production.

One can infer from this finding that there are some characteristics of tasks resulting in equivalent performance of older and younger groups. Certainly the degree of elaboration induced by the task plays a role. A sentence provides much more elaboration than an individual word or cue. In addition, an

encoding task engaging the participant in an active form of learning and problem solving evokes a different type of activation, resulting in enhanced memory performance. Unscrambling a sentence also enhances semantic encoding of material. The findings of this study suggest that tasks with these characteristics have a differential effect on younger and older adults, whether or not generation is a component, providing more benefit to the older than the younger adult.

The data show that there was in fact, a significant decrease in the performance of both groups in Experiment 2 relative to Experiment 1. This suggests that the semantic generation task results in significantly better performance for both groups than the nongenerative semantic task. The semantic generation task also appears to differentially effect younger and older groups, providing the older adult with an added benefit. Comparing these two tasks directly reveals that semantic generation provides a greater benefit to both groups than does a nongenerative task.

To summarize, the results of Experiment 2 show that a nongenerative task resulted in older adults performing on a level equivalent to that of younger adults. Hence, generation is not a necessary component of a task resulting in an equivalent performance between older and younger adults on an explicit recognition memory test. The data also show, however, that for both younger

and older adults, the sentence production generation task provides a greater memorial benefit than does a nongenerative task designed to induce similar semantic processing.

### General Discussion

This study investigated age-related differences in memory performance by comparing older and younger adults on tasks with different processing requirements at encoding. Sentence production was used as a form of generative processing. We predicted that the older group would perform on a level equivalent to that of the younger one because of the extensive elaboration induced by this form of generative processing. This hypothesis received support from the near identical scores found for older and younger adults on explicit memory tests when sentence production was used.

A different task was employed in the second experiment as a means of isolating the role generation played in the results obtained in the first experiment. Sentence construction was selected as an encoding task using sentences but omitting generation. We predicted a general decrease in memory scores from those obtained when sentence production was used. In addition, the older adults were expected to show a greater loss when generation was eliminated from the encoding task. This last prediction was not supported. While a small difference favoring the young was found between the memory

scores, the difference was not statistically significant. It appears that the semantic problem-solving aspects of this task are enough to enhance the memory performance of older adults relative to younger adults, regardless of generation requirements.

Our predictions were based on the view that older individuals utilize their processing resources in a less efficient way than do younger ones ( Craik, 1984). Such a view requires examination of the differences between the behavioral and cognitive proclivities of the older and younger adult across different paradigms. It is generally accepted that the younger adult is equipped with keen observational abilities, greater motivation, knowledge that a verbal task most likely will result in some form of test, and more effective memory strategies for such tests. The older adult, on the other hand, is considered to be farther removed from the activities of the classroom than the younger adult and, therefore, less likely to consider the prospect of memory testing after such tasks. In addition, they are less likely to employ effective encoding strategies for the materials normally used in the laboratory. Thus, when analyzing the memory performance of older and younger adults, in conjunction with other explanations of differences between these two groups, one must keep in mind processing differences. With this in mind, it is not surprising to find differences in older and younger adults' responses to different encoding tasks, and

ultimately, performance as a result of experimental manipulations of processing requirements.

In the levels of processing paradigm, the general finding is that younger adults perform significantly better than do older ones on explicit memory tasks. The yes/no responses required by the encoding tasks often used in the levels of processing paradigm result in the older individual responding in an automatic, even stereotyped fashion. At the same time, the inference from such a view is that since it requires the use of limited processing resources, the younger adult is more likely to spontaneously engage in more extensive processing. It is this processing which results in a more elaborate semantic representation of the word in the younger adult, and ultimately, a better memory performance. The older adult, on the other hand, is less likely to spontaneously engage in such processing. Thus, the difference normally found between age groups on explicit tests of memory with levels of processing encoding tasks are the result of the differences in the extent of processing that has occurred. As suggested by the production deficiency hypothesis ( Craik, 1984; Craik & Jennings 1992), a logical inference from this suggestion is that if the older adults are guided to use more extensive processing, to induce a more elaborate semantic representation of the word, these differences would be eliminated.

It was the extent to which different processing requirements induce a more elaborate encoding that was the major interest of the current study. Specifically, we utilized two tasks designed to induce different “levels of activation” (Klein & Saltz, 1976), or different degrees of semantic activation. The predictions made in the current study resulted from a combination of the processing view of aging and the effects of resulting differing levels of activation. That is, the older adult would be at more of a disadvantage in semantic encoding tasks where less processing was induced at encoding (i.e. levels of processing), while they would benefit more from those tasks guiding the learner to a more elaborative processing (i.e. sentence production).

Sentence production is a derivative of the word generation paradigm although it actually is quite different from standard word generation tasks. The distinguishing feature of this task is that the target word itself is not generated, rather, what is generated are the actual materials used to enhance the word. Thus, the context in which the learning occurs is generated by the participant, not an external source, resulting in increased likelihood it will have meaning to him or her. Hence, at least one aspect of sentence production, contributing to the enhancement of the word’s memorability, is the self-reference associated with it.

A parallel can be drawn between sentence production and a procedure reported by Mantyla (1986) as having enormous benefits to memory performance. In Mantyla's study participants were shown 500 or 600 individual words with instructions to generate properties or features of each word. When these self-generated responses were presented as retrieval cues practically perfect recall resulted. The bases for such high scores were claimed to be compatibility of retrieval cues and distinctiveness. In addition, Mantyla acknowledged that our understanding of memory and remembering can be extended by instructing and encouraging subjects to process information according to their own cognitive structures.

Another advantage of sentence production over previously utilized generation tasks is the amount of generative activity it involves. Fieldler, Lachnit, Fay, & Krug (1992) clearly established that the amount of generative activity affects later recall. They found that as the amount of semantic cueing decreased, memory performance increased. In our sentence production task, the participant was required to generate a whole sentence; hence, it is reasonable to conclude that the individual would derive a greater benefit than generating either one word or a more constrained part of a sentence.

Sentence production guides the learner to a more elaborative encoding of the target word. This induction of better processing at the encoding stage

best explains the different effects found between younger and older adults. It is well established that greater elaboration is an important part of improved memory performance (Hashtroudi, Parker, Luis, & Reisen, 1989; Cherry, Park, Frieske, & Rowley, 1993). Hashtroudi, et al (1989) also found that by including a generative task requiring the subject to generate elaborators of a particular sentence, the differences normally found between older and younger adults were reduced. In their study, the generation task differentially affected younger and older adults, providing a greater benefit to the older ones. They attributed their findings to the fact that they used a less constrained form of generation task than did other studies which reported no difference in effect on older and younger adults. Our findings support and extend these findings.

By using an even less constrained task than Hashtroudi et al (1989), not only did the performance of the older adult approach that of the younger one, but was essentially equal to it (Young adults mean recognition memory score = .88; Old adults mean recognition score = .86). These results were obtained while ceiling effects were minimized; such effects have called similar results into question in the past (see Grix, 1998). An added benefit of sentence production is the apparent ease with which it can be completed. Subjective reports of the subjects involved in this study were that this was a basically easy

task they enjoyed. Such ease is especially important to the older adult who we assume has less processing resources.

The fact that this task differentially benefited older adults supports Craik's (1984) view of the nature of processing deficiencies in older persons. That is, when guided to encode information in a more efficient, elaborate, and less constrained fashion, the performance of older adults on memory tests can be significantly enhanced.

Sentence construction calls for an intermediate level of activation, less than sentence production and more than a typical levels of processing task. Some insight into the processing activities associated with this paradigm can be provided by Graf(1980; 1981; 1982) who employed different tasks involving sentences. Graf viewed such tasks as dependent on relational information about words, particularly the extensive analysis conducted of each word and the relationships among the words. The finding that sentence construction yielded lower scores than sentence production suggests sentence construction does not provide the same benefit, presumably because of the lack of generation. The fact that sentence construction differentially affected the scores of the older and younger groups, providing a greater benefit for the older one, can best be explained by a number of factors.

Because the participant was provided with a sentence framework in sentence construction, it provided greater elaboration and context than standard levels of processing tasks. In addition, due to the more active, problem-solving nature of it, sentence construction induced the older adult to utilize processing resources that lie dormant when they are performing a more passive task. Thus, while extensive generation (i.e. sentence production) is one of the conditions providing greater benefit for the older adult, it is not a necessary one. Our results are generally consistent with the view that another component of a task reducing age related differences in memory performance is to actively involve the older individual in the learning task.

Young/old differences on the explicit test of recognition are normally found in the levels of processing paradigm but were eliminated with the introduction of sentence production and sentence construction. Thus those tasks requiring more cognitive activity, active involvement, and elaboration have differential effects on older and younger adults. The suggestion here is that those tasks with these characteristics mobilize otherwise unused processing resources in the older adult, resulting in performance similar to that of young adults on an explicit memory recognition task. An additional enhancement is provided when the subject is allowed to use a less constrained form of generation.

These findings suggest a reconfiguration of the views of the performance of younger and older adults on explicit memory tasks with different processing requirements. In Table 1 (Haberlandt, 1999), there were relatively few tasks in which no differences between younger and older adults were found. Those tasks in which no differences are found often involve sensory processing, implicit memory and those involving previously learned skills or information. Our results point to the importance of looking at performance as a result of processing across at least two characteristics of the processing task, activation and semantic activation. It is suggested that perhaps older adults show equivalent performance at the “extremes” of activation, those relatively automatic processes (implicit memory tasks) and those requiring a great deal of cognitive activation (sentence construction, production).

These results fit well into the conceptualization of semantic cognitive space advanced by Klein & Saltz (1976), in that meaning is not activated in an all or none fashion, but rather, in different levels. At the more general level (i.e. levels of processing tasks), there are differences in performance between older and younger adults, but at the deeper levels (i.e. sentence production, construction), these differences are eliminated. The fact that both sentence production and construction differentially benefit the older adult while still

being significantly different suggest there is an area of activation under which older adults can perform at the equivalent level of younger ones.

While one must be extremely careful in generalizing from cognitive-behavioral studies such as this one to localization of anatomic substrates, the possibility of future research relating these results to the neuropsychological literature on aging and memory is intriguing. The current data appears to be consistent with the idea that at least some of the deficits resulting from the aging process are due to inefficient processing and use of strategies, and thus, can be linked to frontal lobe functioning.

In 1980, Albert and Kaplan proposed that age-related declines in cognitive functioning are due in part to frontal lobe dysfunction, particularly resembling those found in patients' with right frontal dysfunction. More recently, a number of investigators have explored this possibility, with mixed results.

Stuss, Craik, Dayer, Franchi, and Alexander (1996) conducted a study comparing the memory performance of older people and patients with frontal lesions on a list learning task. They hypothesized that since right-sided damage more than left is associated with impairment in organizational abilities at encoding and deficiencies in output monitoring and maintenance of set at

retrieval; a similar pattern should be observed between normal older adults and patients with right-sided lesions.

In their study, three different groups without neurological deficit were tested: young (mean age = 29 years), middle (mean age = 54 years), and old (mean age = 72 years). Three groups with frontal damage were also tested, a unilateral left (UL) (mean age = 50.9), unilateral right (UR)(mean age = 52.6), and a bilateral group (mean age = 52.0)(BL). Three word lists were used, consisting of 16 concrete picturable nouns, each differing in their structure. The blocked categorized list consisted of four words in each of four semantic categories, with presentation grouped by category. The unblocked categorized list was composed of four words in each of four semantic categories, different from those in the blocked list and presented in random order so that no two words from the same category were sequential. The unrelated list contained sixteen words from sixteen different categories. Immediately following each trial presentation, the participant was required to recall as many words as possible. Each list was presented and recalled four times. Finally, a recognition test was administered approximately sixty minutes after the last free recall of the third list.

The following is a summary of the results most relevant to the present discussion. There were no age-related differences on recognition memory or on

the blocked list recall. On the more difficult lists, however, the performance of the older persons declined. On all measures of the “executive” aspects of the encoding process, for example, strategy, monitoring, and efficiency, the older group performed worse than the middle and younger ones. In terms of the effect of lesion site, on all tasks of memory, the UL and BL groups performed worse than the age-matched middle controls. In addition, the older controls and the UR group had equivalent performance on most tasks, although the UR group was more impaired on most executive measures. Furthermore, on the measure of subjective organization, the UR and older controls had reasonably equivalent performance.

In their discussion, Stuss et al (1996) suggested that these results were consistent with current data on aging and memory. Older people were shown to have modest impairment on list learning tasks, most likely to be manifested on more difficult, less structured lists. In addition, this deficit is equivalent to that seen in patients with damage to their right frontal lobe, but not to that which is seen in patients with left or bilateral frontal damage. Both older and UR groups show a deficit in subjective organization that distinguishes them from younger and middle control groups. Also, the performance of older groups and patients with right frontal damage is approximately equivalent. Thus, it is possible that list learning deficits seen in normal older adults represent poor use of ordering

strategy and this is correlated with deterioration of the right frontal lobe.

However, patients who suffer actual right frontal damage show additional executive impairments in efficiency. Finally, the investigators assert that the hypothesis that reduced learning in normal aging is at least in part due to right frontal dysfunction was partially supported by their findings.

The role of the frontal lobes, particularly the right frontal lobe in the memory process has also been highlighted more recently in imaging studies. For example, Schacter, Savage, Alpert, Rauch, and Albert (1996) performed PET scans while young and elderly subjects attempted to learn two types of word lists. The lists were such that high levels of recall were achieved with one set of word lists, while low levels of recall were achieved with the other. Analyses of the PET data from both young and old participants revealed blood flow increases in the hippocampal formation in comparisons in which the high recall condition was emphasized; bilateral blood flow increases were noted in the high recall minus baseline comparison, and right unilateral increases were seen in the high recall minus low recall comparison. This suggests that the features of recollection indexed by hippocampal activity operate in a similar manner in young and old. Differences between young and old were noted in comparisons of the low recall condition. Most striking was the difference between the groups in the low recall minus baseline comparison, which

produced blood flow increases bilaterally in the anterior frontal lobe for the young participants, but not for the old. By contrast, the older persons demonstrated unilateral blood flow increases in the right posterior frontal lobe and the right motor area. The authors suggested that these differences in frontal activation may reflect differences in retrieval strategies between the two groups.

Another PET study was conducted by Backman et al, (1997), who investigated brain activation in younger (mean age = 24.3 years) and older adults (mean age = 63.4 years) during explicit and implicit retrieval. They also demonstrated significant frontal lobe involvement in explicit memory tasks, as well as prefrontal activation in both older and younger groups.

Thus, substantial evidence exists for postulating a role for the frontal lobes in both younger and older adults. Because of the number of functions this area of the brain is known to be involved in, it makes sense that changes in its integrity would contribute to age-related changes in memory performance.

According to Schacter (1996):

**Difficulties related to the frontal lobe emerge as the most important factor in elderly adults' impaired cognitive performance on several different tests..... rather than resulting from a general decline in all**

aspects of brain function, many memory problems in older adults stem from specific impairments in the frontal lobes (pp.286-287).

The results of the present study suggest that when the cognitive activity required at encoding is more passive in nature (i.e., levels of processing tasks), frontal lobe involvement is less, and therefore, the effect of frontal lobe activation on memory performance is minimized. When the task is a more active one, on the other hand (i.e. sentence production, sentence construction), the result is an increase in frontal activity, with a positive effect on memory performance. Determination of the exact mechanism of this effect is beyond the scope of this study. However, the possibility exists that future studies employing a design similar to that of Stuss, Craik, Dayer, Franchi, & Alexander (1996), where these tasks are used with frontal patients, would answer some of these questions. In addition, a comparison of brain activation, specifically frontal lobe activation, while participants complete both levels of processing and sentence production/construction study tasks would also provide some promising insights.

The current findings suggest some other interesting areas for future research. One would be a more extensive use of the task-comparison methodology (Richardson-Klavehn & Bjork ,1988) to further identify other types of processing task differentially affecting older and younger adults. For

example, Graf (1982) introduced rotated sentences and found that they were remembered just as well as sentences which had to be unscrambled. A direct comparison among these rotated sentences, sentence production, and sentence construction with age as the critical variable might shed further light on the effects of different types of processing.. Another area where our results could be extended is with different neuropsychological impaired patients. For example, it has been suggested that lack of a generation effect might be useful as a diagnostic marker for dementia (Mitchell, Hunt, & Schmitt, 1986). Since sentence production produces such a robust memorial benefit, a relevant question is whether or not such an effect can be observed in a demented or brain damaged patient. Consideration of other factors which might affect cognitive performance in the elderly, for example, estrogen replacement therapy, could also be examined in conjunction with sentence production and sentence construction.

Finally, the current results support a more optimistic view of memory rehabilitation. If different processing tasks and their characteristics and contribution to memory performance can be identified, perhaps they can be integrated into better rehabilitation strategies for those clinical populations with memory deficits.

APPENDIX A

**BACKGROUND QUESTIONNAIRE**

**Subject I.D. Number** \_\_\_\_\_

1. Age \_\_\_\_\_

2. Sex: M      F

3. Number of Years Education/Degree: \_\_\_\_\_

4. Current Medical Conditions:

\_\_\_\_\_  
(Please note what they  
are for)

\_\_\_\_\_

5. Current Medications:

\_\_\_\_\_  
\_\_\_\_\_

6. Are you currently receiving hormone therapy? Y      N (if yes, please name):

7. Do you have a history of head injury?      Y      N

If yes, please explain:

\_\_\_\_\_  
\_\_\_\_\_

8. Do you have/had epilepsy?      Y      N

If yes, please explain:

\_\_\_\_\_  
\_\_\_\_\_

9. Do you have/had any significant Neurological Diseases? (e.g. Stroke,  
Multiple Sclerosis, Parkinson's Disease)?                    Y                    N

If yes, please explain:

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## APPENDIX B

Target words and Word Fragment Completions to be used in Experiment 1. Word Numbers 1 through 64 compose list 1; Word numbers 65 through 128 compose list 2.

1. ATTENDANT, A-T-N-A-T
2. BUTCHER, B-T-H-R
3. ELEPHANT, E-L-E-H-N-
4. FRIEND, F-I-N-
5. JUGGLER, J-G-L-R
6. LOBSTER, L-B-T-R
7. PERFORMER, P-R-O-M-R
8. SINGER, S-N-E-
9. ANIMAL, A-I-A-
10. ARTIST, A-T-S-
11. BUSYBODY, B-S-B-D-
12. DOORMAN, D-O-M-N
13. MONARCH, M-N-R-H
14. MUSICIAN, M-S-C-A-
15. PIANIST, P-A-I-T
16. TROOPS, T-O-P-
17. BAGPIPE, B-G-I-E
18. BUTTER, B-T-E-
19. DAYBREAK, D-Y-R-A-
20. HEADLIGHT, H-A-L-G-T
21. NUTMEG, N-T-E-
22. SCIENCE, S-I-N-E
23. TWEEZERS, T-E-Z-R-
24. VESTIBULE, V-S-I-U-E
25. ALCOHOL, A-C-H-L
26. DAYLIGHT, D-Y-I-H-
27. GALAXY, G-L-X-
28. PRISON, P-I-O
29. PUDDING, P-D-I-G
30. RHAPSODY, R-A-S-D-
31. SAILBOAT, S-I-B-A
32. WINDMILL, W-N-M-L-
33. BACTERIA, B-C-E-I-
34. CREATURE, C-E-T-R-

35. FISHERMAN, F-S-E-M-N
36. GENTLEMAN, G-N-L-M-N
37. LEOPARD, L-O-A-D
38. MAIDEN, M-I-E-
39. PRISONER, P-I-O-E-
40. TEACHER, T-A-H-R
41. ADMIRAL, A-M-R-L
42. ARMADILLO, A-M-D-L-O
43. AUTHOR, A-T-O-
44. CHARLATAN, C-A-L-T-N
45. INFANT, I-F-N-
46. MOSQUITO, M-S-U-T-
47. PHYSICIAN, P-Y-I-I-N
48. SOCIALIST, S-C-A-I-T
49. BARREL, B-R-E-
50. CEREMONY, C-R-M-N-
51. FURNITURE, F-R-I-U-E
52. MAGAZINE, M-G-Z-N-
53. PICTURE, P-C-U-E
54. SEASHORE, S-A-H-R-
55. UMBRELLA, U-B-E-L-
56. WINTER, W-N-E-
57. ACCORDIAN, A-C-R-I-N
58. BUILDING, B-I-D-N-
59. DIAMOND, D-A-O-D
60. LABYRINTH, L-B-R-N-H
61. PROMOTION, P-O-O-I-N
62. RAILROAD, R-I-R-A-
63. SHADOW, S-A-O-
64. SPINACH, S-I-A-H
65. BANKER, B-N-E-
66. BUTTERFLY, B-T-E-F-Y
67. CATTLE, C-T-L-
68. DERELICT, D-R-L-C-
69. HENCHMAN, H-N-H-A-
70. PERSON, P-R-O-
71. PROFESSOR, P-O-E-S-R
72. SETTLER, S-T-L-R
73. ALLIGATOR, A-L-G-T-R
74. BLOSSOM, B-O-S-M

75. DOCTOR, D-C-O-
76. GLUTTON, G-U-T-N
77. OCTOPUS, O-T-P-S
78. PYTHON, P-T-O-
79. SCORPION, S-O-P-O-
80. VICTIM, V-C-I-
81. AGREEMENT, A-R-E-E-T
82. CELLAR, C-L-A-
83. COFFEE, C-F-E-
84. ECONOMY, E-O-O-Y
85. MATERIAL, M-T-R-A-
86. MOISTURE, M-I-T-R-
87. PREVIEW, P-E-I-W
88. VILLAGE, V-L-A-E
89. CARAVAN, C-R-V-N
90. COLONY, C-L-N-
91. HAIRPIN, H-I-P-N
92. HISTORY, H-S-O-Y
93. JOURNAL, J-U-N-L
94. PORTRAIT, P-R-R-I-
95. SONATA, S-N-T-
96. VOCATION, V-C-T-O-
97. BUILDER, B-I-D-R
98. CANDIDATE, C-N-I-A-E
99. CREATOR, C-E-T-R
100. DREAMER, D-E-M-R
101. LECTURER, L-C-U-E-
102. POLICEMAN, P-L-C-M-N
103. RETAILER, R-T-I-E-
104. STUDENT, S-U-E-T
105. ACROBAT, A-R-B-T
106. BANDIT, B-N-I-
107. BUFFOON, B-F-O-N
108. GADFLY, G-D-L-
109. MAMMAL, M-M-A-
110. PHANTOM, P-A-T-M
111. SAVANT, S-V-N-
112. SULTAN, S-L-A-
113. APPLIANCE, A-P-I-N-E
114. CHLORIDE, C-L-R-D-

115. CUISINE, C-I-I-E
116. LANDSCAPE, L-N-S-A-E
117. MIRAGE, M-R-G-
118. OXYGEN, O-Y-E-
119. TRELLIS, T-E-L-S
120. WHISKERS, W-I-K-R-
121. BUNGALOW, B-N-A-O-
122. CLOTHING, C-O-H-N-
123. COURTSHIP, C-U-T-H-P
124. HALLWAY, H-L-W-Y
125. HOSPITAL, H-S-I-A-
126. MOUNTAIN, M-U-T-I-
127. RITUAL, R-T-A-
128. SULPHUR, S-L-H-R

## APPENDIX C

Scrambled sentences used in Experiment 2, containing the same target words as Experiment 1.

1. PLAYED BEAUTIFUL THE MUSICIAN SONATA
2. CONCERNED THE ASTRONOMY GALAXY WITH IS
3. DREAMT THE PRISONER PRISON OF THE ESCAPING
4. ARE THE WILD ARMADILLO ELEPHANT AND THE
5. CAUGHT A LIVE FISHERMAN LOBSTER THE
6. PERFORMED THE SINGER AND PIANIST TOGETHER
7. WAS AN EXCELLENT PROFESSOR LECTURER THE
8. WORKED THE LOCAL PHYSICIAN HOSPITAL IN A
9. READ THE MOVING AUTHOR RHAPSODY THE
10. BIND AND TOGETHER SULPHUR CHLORIDE CAN
11. PROMISED THE CANDIDATE ECONOMY TO FIX
12. BELIEVED THE MOSQUITO BACTERIA TO CARRY IS
13. IS A FORMAL RITUAL COURTSHIP TRADITIONALA
14. HID THE SPOOKY PHANTOM LABYRINTH IN A
15. ARRESTED THE INFAMOUS POLICEMAN HENCHMAN THE
16. ARE THE AND OCTOPUS ALLIGATOR WATER-BOUND
17. BREAKS A NEVER GENTLEMAN AGREEMENT AN
18. DOES A SOCIALIST MONARCH IN NOT A BELIEVE
19. WAS A DORRMAN ATTENDANT AND BATHROOM A THERE
20. ARE A OFTEN CATTLE CARAVAN IN HERDED
21. RECEIVED THE DESERVED BANKER PROMOTION A
22. STERILIZE THE DOCTOR ALCOHOL TO USED
23. REGARDED A SOCIAL GADFLY BUFFOON AS IS A
24. FOOLED THE EASILY CHARLATAN VICTIM THE NAÏVE
25. TRIED THE FRIGHTENED ADMIRAL TROOPS TO THE CALM
26. EFFECTS A GOOD PROFOUNDLY TEACHER STUDENT THE
27. ARE A JUGGLER ACROBAT COORDINATED AND
28. WAS THE LOCATED BUNGALOW SEASHORE AT SUMMER OUR
29. ARE THE WINDMILL SAILBOAT AND WIND-DRIVEN
30. HAVE SHORTLY COFFEE DAYBREAK AFTER PEOPLE MANY
31. USED WHN BUTTER CUISINE OFTEN FINE IS PREPARING
32. LED THE HALLWAY CELLAR INTO THE
33. USED HIS HE WHISKERS TO HIS TWEEZERS REMOVE
34. JOINED THE SMALL SETTLER COLONY THE
35. WAS THE VESTIBULE FURNITURE IN THERE NO

36. IS A WARM CREATURE MAMMAL A BLOODED
37. WAS THE BEAUTIFUL CEREMONY PICTURE OF THE
38. WERE THE BAGPEPE ACCORDION AND LOUD
39. BE THE DANGEROUS SCORPION PYTHON CAN AND
40. WANTS A NO FRIEND BUSYBODY FOR A ONE
41. SPRINKLED THE RICE NUTMEG PUDDING ON SHE THE
42. PUBLISH THE OFFENSIVE MAGAZINE MATERIAL NOT THE DID
43. PLAYED THE EXPERT PREVIEW PERFORMER IN THE
44. PAINTED AN ACCURATE ARTIST PORTRAIT THE
45. CAUGHT THE COLORFUL MAIDEN BUTTERFLY THE
46. SELL THE EXPENSIVE APPLIANCE RETAILER ANY COULD
47. HAVE THE CLEAN DERELICT CLOTHING NOT DID
48. FLED THE QUICK MOUNTAIN ANIMAL TO THE
49. OWNED THE LARGEST SULTAN DIAMON THE
50. EXPERIENCING THE FIRST WINTER INFANT IS HER
51. WAS A BUILDER VOCATION HE BY
52. ATE THE ALL SPINACH CLUTTON THE
53. WORKED THE VILLAGE BUTCHER IN THE
54. ILLUMINATED THE SCARY HEADLIGHT SHADOW THE
55. THROWN THE OFF BUILDING BARREL WAS THE
56. KNEW THE EVERYTHING HISTORY SAVANT ABOUT
57. DESTROYED THE OLD MOISTURE JOURNAL BY WAS
58. TRIED THE RAILROAD BANDIT TO BY ESCAPE
59. WAS THE UNKONW HAIRPIN CREATOR OF ANTIQUE THE
60. LOOKED THE BEAUTIFUL DAYLIGHT LANDSCAPE IN MOST
61. STOOD THE BROKEN UMBRELLA PERSON UNDER THE
62. SAW A REALISTIC DREAMER MIRAGE THE
63. GREW THE ROSE TRELIS BLOSSOM ON THE
64. NEEDS BREATHE OXYGEN ONE IN TO ORDER

## APPENDIX D

### Consent Form

**Name of Research Supervisor:** Dr. Wilma Winnick

**Principle Investigator:** Joseph Vollaro, M.A.

**Departmental Affiliation with Queens College:** Psychology

**Title of Project:** Language processing differences between younger and older adults.

**Date of Approval from Queens College Institutional Committee for the Protection of Human Subjects:**

**Purpose of Study:**

The purpose of this study is to determine whether or not there are differences in the processing of words in healthy young adults (18-35 year-olds) versus healthy older adults (70-89 year-olds).

**Subject Participation:**

As a subject, you will be asked to fill out a short background and health questionnaire. Your name will NOT appear on this form. All responses will be coded, insuring confidentiality of all responses. In addition, you will be asked a number of questions, which will take approximately 5-10 minutes to answer. Finally, you will be asked to perform a number of simple computer tasks involving looking at scrambled words presented on a computer screen and given two different verbal tasks in response to the words. The computer will record all of your responses and the only person to look at this data will be the principal investigator. Once the data is obtained from the computer, your name will no longer appear with it, only your I.D. #. The length of participation will be between 1.5 and 2 hours. All results will be kept in the Principal Investigator's locked file.

**Risks, Dangers, & Benefits:**

There are no risks associated with participation in this research. The benefit that you will derive from participation is that you are helping to advance knowledge in this area of Neuropsychology.

**Informed Consent:**

The investigator has explained my rights to me as a research subject. I understand that if I feel uncomfortable with any procedure at any time I am free to withdraw from the study. I understand that if I am a Psychology 101 student and I do withdraw, I will receive course credit for the amount of time I have participated in the experiment. In addition, there will not be any consequence upon my standing at Queens College (grades, course requirements, job status, or any other institutional privilege or responsibility). If I have any questions about the study I can contact:

Dr. Wilma Winnick and/or Joseph Vollaro, M.A.  
Queens College Psychology Department  
(718) 997-3201 (Dr. Winnick's Office)  
(718) 997-3251 (Cognitive Neuropsychology Lab)  
(718) 428-5283 (Joseph Vollaro, M.A.)

I understand that confidentiality will be preserved to the fullest extent. . Once my participation is over, there will be no records that will connect my identity with specific data or results.

My signature below indicates that I have read and understand this consent form and have been fully informed as to the nature of this research. In addition, it indicates that I understand my participation is fully voluntary and I am free to withdraw at any time.

I consent to the retention of information gathered during this study and to the publication of results based on this information given that my anonymity and confidentiality are preserved.

I have a right to a copy of this consent form and may inspect a copy of the Institutional Assurance for the protection of Human Subjects filed by the Research Foundation of CUNY with the U.S. Department of Health and Human Services.

If you have any questions about your rights as a participant in this study, you may contact the Office of Research and Sponsored Programs at 718-997-5400.

Participant's Signature:

\_\_\_\_\_

Participant's Name: (please print or type)

\_\_\_\_\_

Researcher's Signature:

\_\_\_\_\_

Researcher's Name: Joseph Vollaro, M.A.

Date: \_\_\_\_\_

New York City, New York

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