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REDUCED PROCESSING RESOURCES, ORGANIZATION, ELABORATION AND MEMORY PERFORMANCE

by

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A thesis submitted in conformity with the requirements for the degree of Master of Arts
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The goal of the current research was to examine the effect of divided attention on memory. Previous research (Craik, unpublished data) demonstrated that when attention is divided at encoding, subsequent memory performance is poorer than would be expected, given the extent of elaboration that is achieved. It was proposed divided attention interferes with organizational processing, in addition to elaboration, and that both aspects of encoding must be considered in order to accurately predict recall under full and divided attention conditions. To test this proposal, three experiments were conducted that examined elaboration, organization and subsequent memory performance, under full and divided attention. The results did not support the proposal; recall in the divided attention condition was less than would be expected based on the extent of elaboration and organization achieved at encoding. The possibility that divided attention interferes with some other aspect of memory processes, such as consolidation, is discussed.
Reduced Processing Resources, Organization, Elaboration and Memory Performance

A processing view of memory, such as advocated by Craik (1983) represents a change from the conception of memory as a static “thing” – e.g. a trace or record deposited in a store – to the alternative conception of memory as a dynamic action, similar to perceiving and thinking. According to this view, processing of information and events results in subtle alterations of the whole cognitive system, increasing the probability that the same pattern of activation will occur on subsequent occasions. Encoding is seen as “a widely distributed change in the system’s potential to respond in a given way,” (Craik, 1983, p. 107) and retrieval as the successful reinstatement of the encoding processes. This again is a change from the view of retrieval as a search for a wanted record or trace. The processes involved in encoding are proposed to be the very same as those involved in general cognition, such as discrimination, categorization and comprehension; there is no specific cognitive process which corresponds to memorization. In fact, the only process that can meaningfully be labeled a memory process is that of retrieval. Memory is therefore not a self-contained module, but rather integrated with and the natural outcome of the full range of processes encompassed by general cognition.

Within this framework, various factors have been proposed to affect memory performance, including stimulus factors (e.g. inherent meaningfulness or distinctiveness of the to-be-remembered information), congruity of the stimulus with the cognitive system (e.g. level of relevant knowledge and expertise), quality of the cognitive processes involved in encoding (e.g. depth and elaboration of processing [Craik & Tulving, 1975]),
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and congruity between encoding and retrieval processes (e.g. transfer appropriate processing [Morris, Bransford & Franks, 1977], and encoding specificity [Tulving & Thomson, 1973]). The focus of the present research is on the main effect of encoding processes on memory performance.

**Qualitative Dimensions of Encoding Processes**

Perhaps the most widely discussed qualitative dimension of cognitive processes is that of “depth.” Craik and Lockhart (1972) proposed that the cognitive system is structured hierarchically and that incoming information is processed to different levels of analysis. “Shallow” levels of processing are concerned with sensory and physical aspects of stimuli, whereas “deeper” levels of processing are progressively more abstract, semantic and associative in nature. Perception and comprehension of stimuli most likely involves both “bottom-up” sensory-to-semantic processing and “top-down” conceptually driven processing, with processing at different levels temporally parallel or partially overlapping. It is further proposed that deeper processing leads to better memory performance. In a series of experiments carried out by Craik and Tulving (1975) to illustrate levels of processing ideas, participants were instructed to answer yes-no questions about stimulus words, relating to the case the word was written in, the rhyming characteristics of the word, or its semantic nature. The questions were designed to serve as orienting tasks that would induce shallow processing (case questions), deeper phonemic processing (rhyming questions) or even deeper semantic processing. Recall and recognition of the words were substantially affected by the nature of the questions, with deep, semantic processing leading to memory performance that was two to six times higher than levels associated with shallow processing.
Craik and Tulving (1975) proposed a second qualitative dimension of cognitive processing, "elaboration," to describe the richness or extensiveness of processing that occurs at any given level. The authors attempted to manipulate encoding elaboration by asking participants "sentence" questions (e.g. "Would the word 'watch' fit in the following sentence: 'He dropped the _____'?"), and varying the complexity of the sentences. It was predicted that more complex sentences (e.g. "The old man hobbled across the room and picked up the valuable _____ from the mahogany table") would lead to more elaborate encoding and thus superior memory performance. This is exactly what was found, with complex sentences leading to recall levels that were up to twice as high as levels associated with simple sentences.

Craik and Tulving (1975) take the view that both dimensions, depth and elaboration, are necessary to explain the effect of encoding processes on subsequent memory performance. While depth refers to qualitatively different forms of processing, elaboration refers to the richness or extensiveness of processing at any given level. The difference between the two is exemplified by the comparison between proofreading and reading for gist: proofreading involves extensive processing at the relatively shallow level of lexical and visual features, with little attention to meaning, whereas reading for gist requires extensive processing at a deeper, more conceptual level, with little processing of features such as spelling. Benefits to memory performance conferred by elaboration have been related to the concept of distinctiveness (Craik, 1977; Jacoby & Craik, 1979; Moscovitch & Craik, 1976). The proposal is that more elaborative encoding leads to more distinctive encoding, which in turn is easier to recapitulate at retrieval. Just as a distinctive stimulus stands out against a background of different material, and is
therefore easier to detect, it is possible that a distinct encoding may be contrasted to
dissimilar encoded episodes and thereby more easily retrieved. Another possibility,
suggested by Anderson (1976) is that extensive elaboration leads to a redundant network
of encoded information, which increases the chances of successful retrieval.

**Attentional Demands of Encoding Processes**

Experiments in which encoding processes are performed simultaneously with a
secondary task (i.e. encoding occurs under conditions of divided attention) suggest that
deeper and more elaborative processing requires more attentional capacity or "processing
resources." Assuming that processing resources are limited, the more demanding an
encoding task is, the more a simultaneously performed task will be impaired. In an
experiment based on this logic, Johnston and Heinz (1978) found that reaction time to a
light stimulus was slowed when participants were making semantic judgements about
simultaneously presented word stimuli, compared to when participants were making
sensory judgements. Similarly Eysenck and Eysenck (1979) demonstrated that simple
reaction time increased when a concurrent memory task required deeper or more
elaborative processing. The general conclusion is that deeper and more elaborate
processing necessitates the expenditure of greater amounts of processing resource. At the
same time, it should be noted that stimulus characteristics also appear to play a role in the
amount of processing resources required to achieve deep elaborative processing. Stimuli
which are inherently meaningful, or presented in a particularly meaningful context, may
require relatively few resources to be deeply encoded (Lockhart & Craik, 1990).

Divided attention studies (e.g. Murdock, 1965; Anderson & Craik, 1974;
Baddeley, Lewis, Eldridge, & Thomson, 1984) have also been used to demonstrate that
when processing resources are taken away from the memory task by a secondary task, memory performance suffers. For example, in the Anderson and Craik study, participants attempted to learn lists of words while concurrently performing a visual choice reaction time task. Memory performance was later assessed via free recall. The difficulty of the reaction time task was systematically varied by increasing the number of possible alternatives. The results clearly indicated that the more difficult the reaction time task (and hence the fewer resources available for encoding), the worse the memory performance. Very similar results have been obtained when the memory performance of control groups is compared to that of amnesics (Baddeley & Warrington, 1970), intoxicated participants (Jones, 1973), and older adults (Craik, 1968). These findings suggest that divided attention acts to mimic the deficiencies in memory performance associated with these various conditions. Craik (1982) speculated that a common factor underlying all these conditions is a reduction in the available processing resources, and that this in turn leads to qualitative changes in the nature of encoding processes; deep and elaborative processing, requiring more resources, is less likely to occur. In other words, deficiencies in performance may be attributable to an initial failure to process information deeply and elaborately at encoding, a failure to process retrieval information deeply and elaborately, or a failure to reestablish encoding processes at the time of retrieval.

In the case of aging, research findings (e.g. Eysenck, 1974; Cohen 1979, Till & Walsh, 1980) have indicated that older adults tend to engage in less deep and elaborative processing than young adults. For example, Eysenck (1974) gave older and younger participants various orienting tasks designed to induce relatively shallow processing
(counting letters or generating rhymes) or deeper processing (generating appropriate adjectives or images) of word stimuli. When participants were later asked to recall the stimulus words, older adults exhibited an increasing decrement in memory performance, relative to younger adults, from the shallow orienting tasks to the deeper orienting tasks. The greatest age-related decrement in memory performance was found when participants were simply told to learn the words for later recall. Eysenck interpreted these results as strong evidence that under relatively normal learning circumstances, young adults spontaneously engage in deep processing, whereas older adults do not.

Guidance of Encoding Processes and Deficient Memory Performance

Further evidence (e.g. White, cited in Craik, 1977; Lauer, 1975; Zelinski, Walsh & Thompson, 1978) suggests that memory deficiencies associated with aging can be at least partially overcome if processing is guided both at input (by means of an orienting task) and at retrieval (by providing optimal retrieval information, such as in a recognition test). For example, Perlmutter (1978) measured age differences in recognition and recall after intentional learning or after a semantic orienting task (generating free associations to each stimulus word). Age decrements in performance were smallest when the semantic orienting task was coupled with a recognition test. Similar improvements in memory performance have been reported when processing is guided with intoxicated participants (Hashtroudi, Parker, DeLisi, & Wyatt, 1983) and with young participants working under divided attention conditions (Craik & Byrd, 1982). These findings suggest that at least in the cases of aging, intoxication, and divided attention, failure to process deeply and elaborately does not represent a complete inability to carry out deeper, more elaborative processing, but is better characterized as a processing inefficiency. Semantic orienting
tasks may act to utilize the available processing capacity more efficiently than participants can on their own, utilizing self-initiated learning operations (Craik, 1983, 1986). In other words, participants are not aware of how best to utilize limited resources in order to achieve optimal memory performance, and orienting tasks serve to overcome this failure of meta-memory. However, in the case of amnesia, Cermak (1975) reports that amnesiacs are as successful as controls in performing semantic orienting tasks, and yet memory performance remains deficient. This later finding suggests the necessity of postulating the existence of some further "consolidation" process that occurs between initial processing and later retrieval (Craik & Simon, 1980).

**Reduced Processing Resources and Qualitative Changes in Encoding**

In interpreting the results of their study of memory and divided attention, Baddeley, Lewis, Eldridge and Thomson (1984) propose that declines in memory performance associated with division of attention do not necessarily represent qualitative changes in encoding and retrieval processes, but simply reflect the fact that when attention is divided, there is less time available for processing. This proposal assumes that memory performance can be predicted by the total amount of time available for encoding, as argued by Cooper and Pantle (1967), and that time used up by the secondary task is not available for encoding. Craik, Govoni, Naveh-Benjamin and Anderson (1996) attempted to test this hypothesis directly as part of a series of experiments examining the effects of dividing attention at encoding and retrieval on memory performance. Encoding tasks involved auditory presentation of lists of words or word pairs to be later recalled orally, while the secondary task involved manual responses to a continuous visual reaction time task. By presenting the word lists under full
attention conditions at different rates (.75, 1.5, 2.5 and 4.0 seconds per word), Craik et al were able to generate a "calibration function" relating encoding time to later retrieval. It was reasoned that if memory performance is indeed simply a function of the time available for encoding processes, than it should be possible to predict memory performance under conditions of divided attention from the amount of time remaining after subtracting out time used up by the secondary task. Available time was estimated by calculating how much response times to the secondary reaction time task slowed, compared to performance on the reaction time task alone.

For example, if the average response time to the reaction time task alone was found to be 400 ms, while the average response time under dual-task conditions was 600ms, it was assumed that 200ms was available for encoding processes. Craik et al further assumed that the mechanical motor time in each RT response was also available for encoding processes; only the decision time was unavailable. Using press rate RTs as an estimate of motor time, a further 182 ms/RT was added to encoding time. The amount of time available for encoding was thereby brought up to approximately 64% of the total response time. Therefore, if under divided attention conditions each word was presented for a total of four seconds, it was assumed that 2.5 seconds (0.64 X 4 s) was available for encoding processes.

If Baddeley et al's hypothesis is correct, 2.5 s entered into the previously generated calibration function relating encoding time to memory performance should produce a retrieval rate equivalent to that obtained under conditions of divided attention where each word is presented for four seconds. However, this is not what Craik et al found. Memory performance was found to be poorer than it should be, given the
estimated time available for encoding. This was especially true when participants were asked to emphasize the reaction time task more than the memory task. One of the speculative explanations offered by Craik et al is that “participants are unable to encode the words deeply enough under dual-task conditions . . . and that this shift in the qualitative type of encoding leads to poorer recall and recognition.” These findings therefore suggest that deficiencies in memory performance under conditions of divided attention can not be explained simply in terms of less time available for encoding processes, rather the reduction in available processing resources has led to a qualitative change in processing operations.

Craik (unpublished data) attempted to investigate further the relationship between reduction of processing resources, qualitative changes in processing, and subsequent memory performance using a similar logic. In this case, the memory task involved orally generating sentences from word pairs; the first word from each pair later served as the cue in a cued recall task. Manual response to a continuous visual reaction time task was again used as the secondary task. Three independent judges later rated each sentence on the elaborateness of the connection formed between each pair of words. Data from the full attention condition were then used to generate a function relating extent of elaboration to later memory performance. It was assumed that the instructions to generate sentences required all the participants to process the word pairs to the same depth of analysis, in both full and divided attention conditions, and that only elaboration would suffer from the reduction of available processing resources. Craik reasoned that if deficiencies in memory performance under conditions of divided attention were attributable to qualitative changes in encoding processes, memory performance could be
predicted by entering the average extent of achieved elaboration into the previously generated function relating elaboration and memory performance. In other words, with fewer resources, the degree of elaboration would be curtailed, and subsequent memory would reflect the actual degree of elaboration achieved.

Again, however, memory performance was found to be poorer than it should be, based on the extent of elaboration that was achieved. Craik offered two possible explanations for this result (personal communication, September 1997). First, if there is indeed some sort of "consolidation" process which occurs between encoding and retrieval, as suggested by research on amnesiacs, it is possible that reducing processing resources by dividing attention interferes with consolidation as well as encoding processes. A second possibility is that elaboration and depth do not fully capture all of the dimensions of processing that are necessary to explain the main effect of encoding processes on subsequent memory performance.

Organization as an Additional Dimension of Encoding Processes

Related to the second explanation, Hunt and Einstein (1981, see also Einstein & Hunt, 1980) proposed that in addition to depth and elaboration, a distinction can be made between individual-item processing and relational processing. While individual-item processing focuses on item-specific information, relational processing involves the "abstraction of relational information shared by elements or events present at input" (p. 497). Hunt and Einstein further argue that both forms of processing are necessary for optimal memory performance, and attempted to demonstrate this empirically. Participants were presented with a list of words and asked to perform either a relational orienting task (sorting the words into taxonomic categories), an individual item orienting
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task (rating items for pleasantness) or both orienting tasks. To control for the additional amount of processing in the group performing both relational and individual item processing, two control groups were included where participants performed the same orienting task twice. Later recall for stimulus words was compared between the five groups. Participants who performed both individual item and relational orienting tasks exhibited better memory performance, as measured by free recall, than participants who performed only one type of orienting task, even when the same orienting task was performed twice. It was further found that individual item and relational orienting tasks had a differential effect on other dependent measures such as clustering, recognition, and recall as a function of typicality. Based on these results, Hunt and Einstein concluded that relational and individual item processing are in fact two distinct forms of processing and that both forms of processing are necessary for optimal memory performance.

Further evidence for the importance of relational or organizational processing comes from various sources. McDaniel and Masson (1977) looked at depth and organization of processing in the context of intentional learning versus incidental learning through orienting tasks. When the incidental orienting task induced only individual-item semantic processing, intentional learning resulted in better memory performance after a twenty-four hour delay. However, when the orienting task was changed to encourage both individual-item semantic processing and organizational processing, memory performance was equivalent for both types of learning. In contrast, several studies of aging (Hultsch, 1971, Laurence, 1967) indicate that older adults fail to establish adequate inter-item relationships when encoding a list of items for later recall. Taken together, these findings suggest that under relatively normal learning circumstances, younger
adults spontaneously engage in organizational, as well as deep and elaborative processing, but older adults do not, perhaps because of a deficit in processing resources. The negative impact of reduced processing resources on organizational processing is demonstrated by a divided attention study conducted by Park and Smith (1989). Organizational processing of visually presented stimulus words, as measured by clustering in free recall, was found to be reduced when attention was divided at encoding.

The purpose of the present series of experiments was to investigate further the relationship between reduced processing resources, qualitative changes in encoding processes, and subsequent memory performance, focusing on the role of organizational processing. Two key proposals were made. First, it was proposed that the main effect of encoding processes on subsequent recall can be fully explained in terms of the qualitative dimensions of depth, elaboration and organization of processing. Second, it was proposed that dividing attention at encoding interferes with later memory performance by producing qualitative changes in the depth, elaboration and organization of encoding processes. Depending on the specific encoding processes that occur, qualitative change associated with division of attention may involve only one or two of these three dimensions, but all three dimensions must be taken into account in order to explain fully the effect of dividing attention on memory performance.

**Experiment 1**

In order to test these proposals, Experiment 1 (E1) was modeled somewhat on Craik’s unpublished experiment in which a calibration function was generated relating extensiveness of elaboration to memory performance. It was hypothesized that Craik’s function failed to predict performance accurately under divided attention conditions.
because it failed to incorporate organizational processing into the equation. Thus, the
intent of E1 was to generate a function that related both extensiveness of elaboration and
organizational processing to memory performance. Similar to the Craik study, the basic
memory task involved sentence generation. Additionally, the participants were asked to
make each sentence part of an ongoing story. This allowed organizational processing to
be assessed in addition to elaboration. Again, it was assumed that sentence generation
required each participant to achieve the same depth of processing, in both full and
divided attention conditions, and that only elaboration and organization would suffer
from the reduction in available processing resources. It was predicted that a) on average,
less extensive organization and elaboration would be achieved under divided attention
conditions, and b) memory performance under the divided attention condition could be
accurately predicted by entering the average levels of achieved organization and
elaboration into the function generated with data from the full attention condition,
relating organization and elaboration to memory performance.

If the results bear out this prediction, support would be provided for the proposal
that a) the main effect of encoding processes on memory performance can be fully
described in terms of the processing dimensions of depth, elaboration and organization,
and that b) dividing attention at encoding interferes with memory performance by
reducing processing resources which in turn produces qualitative changes in the above
mentioned dimensions of encoding processes. If the function relating elaborateness and
organization of encoding to memory performance fails to predict memory performance
under conditions of divided attention, the findings would instead suggest one of several
possibilities. First, perhaps the assumption that sentence generation required participants
to achieve the same depth of processing under both full and divided attention is wrong, although this does not seem likely. If participants in the divided attention condition were at all able to generate coherent sentences, they must have at least processed the stimulus information to the semantic level. It is not clear what kind of processing participants in the full attention condition might have achieved that could be construed as deeper than semantic. Secondly, it is possible that there is yet another dimension of cognitive processing, beyond depth, elaboration and organization that is necessary to fully explain the main effect of encoding processes on memory performance. Finally, it is possible that reduced processing resources interfere with some additional aspect of memory, beyond encoding processes, such as a consolidation process that occurs between encoding and retrieval.

Method

Participants

Thirty-two university students (24 women and 8 men, mean age = 21.5 years) volunteered to participate. Volunteers received course credit for participation.

Materials

Stimuli for the memory task were 66 two-syllable common concrete nouns. The words were organized into two completely randomized orders and programmed to appear on an IBM laptop computer, in capital letters in the middle of the screen. The words were then projected onto a large screen via an LCD panel and overhead projector. Mel2 was the programming language used. Stimuli for the digit monitoring task included all the single digits from zero to nine. Twelve hundred digits were spoken into a tape recorder at a rate of one digit every 1.5 seconds, which produced a thirty minute long
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recording. The digits occurred in a random order, except for the following considerations: The recording included 80 target sequences, defined as three odd digits in a row. The first sixty targets were unique, and the last twenty were re-sampled from the beginning. Lags between target sequences ranged from 6 to 19 digits, with a mean of 12.5 digits.

Experimental Tasks

For the encoding task, participants were presented with a series of 60 words, one at a time, for 30 seconds each. Half of the participants in each condition were presented with words in the first randomized order, while the other half were presented with the second order. Participants were instructed to make up one sentence using each word and to write it down in the space provided on the answer sheet in front of them. In addition, participants were instructed to make each sentence part of an ongoing story. The words were sub-divided into groups of six, and participants were instructed to make up a different story for each group. Thus, each participant wrote a total of ten stories, each six sentences long. Participants were informed that there would be a memory test for the stimulus words later, but not to try to memorize the words intentionally, simply to focus on making their stories as interesting and coherent as possible.

For the digit monitoring task, participants were instructed to listen to a recording of single digits being spoken aloud at a rate of one every 1 ½ seconds, and when they heard three odd digits in a row, to write the three digits down in the left hand margin of their answer sheet.

For the recall task, participants were instructed to write down as many of the stimulus words as they could remember. They were further instructed that it was very
important that they write the words down in the order that they recalled them. This was necessary in order to calculate an accurate clustering score, which was used to measure organizational processing. Participants were allowed 10 minutes for this task.

**Design and Procedure**

A between participants design was used with attentional condition at encoding (full or divided) as the independent variable. Participants were tested in groups of two to five people. In the full attention condition, the nature of the encoding task was described to the participants, who then wrote six practice sentences (comprising one practice story). During the main part of the experiment, the encoding task was performed first, followed by a sixty-second period in which participants were instructed to count backwards from the number 2,000 by seven, and the recall task was performed last.

In the divided attention condition, both the encoding task and the digit monitoring task were described to the participants, who then practiced each task separately. During the main part of experiment, the digit monitoring task was performed simultaneously with the encoding task. Participants in this condition were instructed to attempt to perform perfectly on the digit monitoring task and devote whatever resources they had left to the encoding task. After the encoding task was completed, participants were instructed to count backwards from the number 2,000 by seven for a period of sixty seconds, and the recall task was performed last.

Three dependent measures looked at memory performance, extensiveness of elaboration, and organizational processing. Memory performance was measured in terms of proportion correct recall, extensiveness of elaboration was measured by average sentence length (based on the assumption that longer sentences are more complex and
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require more elaborative processing), and organization was measured by clustering by story groups in recall. Clustering scores were calculated using the Adjusted Ratio of Clustering (ARC) suggested by Roenker, Thompson and Brown (1971).

Results

The results of E1 are summarized in Table 1. Performance on the digit monitoring task was measured in terms of the proportion of target sequences accurately detected. Participants in the divided attention condition achieved a mean proportion of 0.58.

Unexpectedly, there was no decrement in memory performance in the divided attention condition. In fact, the trend was slightly in the opposite direction: participants in the divided attention condition recalled an average proportion of 0.63 of the words, compared to 0.61 in the full attention condition, although this difference was not statistically significant, t(30) = -.36, p > .05. Given that the average hit rate on the secondary digit monitoring task was somewhat low, it is possible that the participants in the divided attention condition were devoting the majority of their processing resources to the encoding task while neglecting the secondary task, thereby explaining the lack of an observed divided attention effect. To investigate this possibility, participants’ performance on the digit monitoring task during the encoding of each word was examined: if a participant failed to detect more than half of the target sequences occurring during the encoding of a word, the word was excluded from the calculation of the participant’s recall performance. In this way, memory performance was measured only for words encoded under truly divided attention conditions. Using these adjusted rates of recall for participants in the divided attention condition, mean proportion correct recall
was found to be slightly higher than before, at 0.65. The difference between the original and adjusted scores was not significant, \( t(14) = -0.86, p > .05 \). Thus it appears that inattentiveness to the secondary task cannot account for the lack of a divided attention effect.

Also contrary to what was predicted, but consistent with the pattern of recall, organizational processing, measured by clustering in recall, was more extensive in the divided attention condition (0.67) than in the full attention condition (0.58); this difference was statistically insignificant as well, \( t(30) = -1.46, p > .05 \). Interestingly, there was a relatively large, statistically significant correlation between clustering scores and proportion recalled in the full attention condition (\( r = 0.63, p < .01 \)), compared with virtually no correlation in the divided attention condition (\( r = -0.01, p > .05 \); see Figure 1).

Mean sentence length was longer in the full attention condition than the divided attention condition (11.33 words versus 10.06, respectively), suggesting that more extensive elaboration was achieved in the full attention condition. However, this difference did not quite reach significance, \( t(30) = 1.79, p = 0.08 \). Furthermore, mean sentence length was insignificantly and somewhat negatively correlated with proportion recalled in both full (\( r = -0.34, p > .05 \)) and divided attention (\( r = -0.11, p > .05 \)) conditions (see Figure 2), and therefore may be a poor measure of extent of elaboration.

Due to the surprising nature of these results, no attempt was made to generate a function relating elaboration and organization to memory performance.
Discussion

There are at least two possible explanations for the failure to find an effect of dividing attention on memory performance. First, it is possible that the procedure failed to produce any meaningful reduction in processing resources. Perhaps the thirty second interval between stimulus words allowed participants ample time to perform both tasks without much conflict. However, the fact that participants performed far from perfectly on both the digit monitoring task and the recall task argues against this possibility. A second possibility is that the story-writing orienting task necessitated organizational and elaborative processing at a level equivalent to that achieved under full attention conditions. Put another way, the orienting task may have acted to utilize the reduced amount of processing capacity so efficiently that participants were able to achieve optimal encoding processes despite the division of attention. Experiment 2 was an attempt to investigate the second possibility.

Experiment 2

The purpose of Experiment 2 (E2) was to test the hypothesis suggested by E1 that an orienting task which induces both deep, elaborative processing and organizational processing is sufficient to overcome any deficits in memory performance that would normally result from division of attention at encoding. Towards this end, E2 simply duplicated the procedure of the pilot study, with one key change: the instructions to make each sentence part of an ongoing story were eliminated. Thus, the orienting task was changed such that organizational processing would no longer be induced, but the task otherwise remained virtually the same. The prediction was that without the induction of organizational processing, the orienting task would no longer be sufficient to overcome
the handicap of reduced processing resources, and a decline in memory performance would be observed under conditions of divided attention.

Method

Participants

34 university students (30 women and 4 men, mean age = 21.8) volunteered to participate. Volunteers received course credit for participation.

Materials, Design and Procedure

E2 exactly duplicated the procedure of E2, with the exception that the instructions to make each sentence part of an ongoing story were excluded.

Results

The results of E2 are summarized in Table 1. Participants of E2 performed very similarly to participants of E1 on the digit monitoring task, with a mean proportion of 0.60 target sequences accurately detected (compared with 0.58 in E1). Also similar to E1, mean sentence length was greater in the full attention condition (11.26 words) than in the divided attention condition (9.39 words), perhaps suggesting that more extensive elaboration was achieved in the full attention condition. In this case the difference did reach significance, $t(32) = 2.51, p < .05$. Mean sentence length was positively but insignificantly correlated with proportion recalled in both full ($r = 0.25, p > .05$) and divided attention ($r = 0.11, p > .05$) conditions (see Figure 3). Again, it appears that sentence length is neither a consistent nor powerful measure of extent of elaboration.

In contrast to E1, and of the most interest here, a statistically significant decline in memory performance was observed in the divided attention condition. Mean
Proportion recall in the full attention condition was 0.45, compared with 0.35 in the divided attention condition, $t(32) = 2.81, p < .01$.

**Discussion**

Taken together, the results of E1 and E2 suggest that deficiencies in memory performance associated with reduced processing resources can be overcome by encoding tasks which necessitate deep, elaborative and organizational processing. Further evidence in also provided for the contention that organization is a qualitative aspect of encoding processes distinct from depth and elaboration, and that superior memory performance occurs when extensive processing is carried out along all three dimensions. Even in the full attention condition of E2, memory performance was inferior to that observed in E1. However, because there was no effect of DA on memory performance in E1 and organizational processing was not measured in E2, there is still no direct evidence for the proposal that dividing attention at encoding interferes with later memory performance simply by producing qualitative changes in the depth, elaboration and organization of encoding processes. A further problem with both E1 and E2 was the inadequacy of using sentence length as a measure of extensiveness of elaboration. Elaborative processing may be more effectively measured by a panel of judges who rate the elaborateness of participants' sentences, or by subjective ratings generated by the participants themselves. Experiment 3 was an attempt to overcome the shortcomings of E1 and E2.

**Experiment 3**

The goal of Experiment 3 (E3) was to produce a decline in memory performance by dividing attention, while at the same time obtaining an adequate measure of both
organization and elaboration. To this end, an encoding task was designed that allowed participants to engage in organizational and elaborative processing, but did not necessitate such extensive processing so as to overcome the detrimental effects of reduced processing resources. Instead of generating sentences, participants were asked to generate mental images in response to stimulus words, and to provide a subjective rating of how elaborate each image was. Stimulus words were drawn from several categories of objects (e.g. vegetables), and the order of presentation was randomized such that exemplars from different categories were intermixed. Participants were not explicitly informed of this implicit organizational structure of the list, nor instructed to attempt to group the words into categories, although pilot data indicated that participants did tend to cluster the words according to category in their recall. Organizational processing was therefore measured by clustering in recall, as in E1, and elaborative processing was measured by participants’ subjective ratings. Digit monitoring was again used as the secondary task. This procedure thus allowed a measure of both elaborative and organizational processing to be obtained, without encouraging an excessive amount of processing.

As in E1 and E2, it was assumed that the encoding task required all participants to achieve the same depth of processing, and that only elaboration and organization would be detrimentally effected by dividing attention. The predictions of E3 were exactly the same as E1. That is, a) on average, less extensive organization and elaboration would be achieved in the divided attention condition, and b) memory performance under the divided attention condition could be accurately predicted by entering the average levels
of achieved organization and elaboration into a function generated with data from the full
attention condition, relating organization and elaboration to memory performance.

Method

Participants

Twenty-four university students (18 women and 6 men, mean age = 24.1 years) volunteered to participate. Volunteers received course credit for participation.

Materials

Stimuli for the memory task were 84 two-syllable concrete nouns. Stimulus words were drawn from 14 distinct categories listed in the Battig and Montague (1969) category norms. The words were divided into two lists, A and B, containing 42 words and 7 categories each. Each list was then organized into two different completely randomized orders. Mel2 was used to program the words to appear on a desktop personal computer, in capital letters in the middle of the screen. Stimuli for the digit monitoring task were exactly the same as described in the method section of E1.

Experimental Tasks

For the encoding tasks participants were presented with a series of 42 words from either list A or list B, one at a time, for seven seconds each. Half the participants were presented with the words in the first randomized order, while the other half were presented with the second order. Participants were instructed to generate a mental image in response to each stimulus word, and to rate how elaborate each image was on a scale from 0 (no image generated) to 6 (maximum level of elaboration) by circling the appropriate number on the space provided on the answer sheet in front of them.
Participants were informed that there would be a memory test for the stimulus words later, and that they should use the mental imaging task to help them memorize the words.

For the digit monitoring task, participants were instructed to listen to a recording of digits being spoken aloud, and when they heard three odd digits in a row, to write the three digits down in the designated column on the right hand side of their answer sheet.

For the recall task, participants were instructed to write down as many of the stimulus words as they could recall, in the order that they recalled them. Participants were allowed five minutes for this task.

**Design and Procedure**

Participants were tested in groups of two to three people. Encoding condition (full or divided) acted as the independent variable and a within participants design was used: each participant encoded one word list under full attention and the second word list under divided attention. During the first half of the experiment, participants encoded and recalled one word list (A or B); during the second half participants encoded and recalled the second word list. Order of encoding condition (full-divided or divided-full) as well as order of list presentation (A-B or B-A) was counterbalanced across participants. In the full attention condition, participants were instructed to focus all of their attention on the encoding task. In the divided attention condition, participants performed the digit monitoring task simultaneously with the encoding task; participants were instructed to attempt to perform perfectly on the digit monitoring task, and to devote whatever resources they had left over to the encoding task. In both halves of the experiment, a 60 second period elapsed between encoding and recall during which participants were instructed to count backwards from 2,000 by the number 3 or the number 7 (a different
number was given for each half of the experiment). All of the tasks involved were described to the participants before the experiment began.

Three dependent measures assessed memory performance, extensiveness of elaboration and organizational processing. Memory performance was measured in terms of proportion correct recall, elaboration was measured by the subjective ratings given by the participants, and organization was measured by clustering by category in recall. As in E1, clustering was calculated using ARC.

**Results**

The results of E3 are summarized in Table 1. Participants of E3 performed somewhat better than participants of E1 and E2 on the digit monitoring task. The mean proportion of target sequences accurately detected was 0.75, compared with 0.58 and 0.60 in E1 and E2. Unlike E1, but similar to E2, memory performance declined in the divided attention condition of E3. Mean proportion correct recall was 0.61 in the full attention condition, compared with 0.35 in the divided attention condition, $t(23) = -10.27, p < .01$. As predicted, less elaboration and organization was achieved in the divided attention condition than the full attention condition. Subjective ratings of elaboration averaged 3.5 under full attention, compared with 2.9 under divided attention, $t(23) = -3.33, p < .01$. The decline in mean clustering scores, from 0.65 under full attention to 0.50 under divided attention, did not quite reach statistical significance, $t(23) = -1.62, p = 0.12$. Elaboration ratings were positively correlated with proportion recall in both the full attention ($r = 0.44, p < .05$) and divided attention ($r = 0.46, p < .05$) conditions (see Figure 4). No correlation between clustering scores and proportion recalled was found in the full attention condition ($r = -0.03, p > .05$); a statistically
insignificant positive correlation was found in the divided attention condition ($r = 0.24$, $p > .05$; see Figure 5).

When elaboration ratings were equated, the probability of recalling a particular word remained consistently lower in the divided attention condition, compared to the full attention condition. This finding is illustrated in Figure 6, which shows the proportion of words recalled at each level of elaboration, pooled across participants, under conditions of full and divided attention. A two by seven factorial analysis of pooled recall proportions revealed significant main effects of both level of elaboration, $F(6,6) = 19.8$, $p < .05$, and attentional condition, $F(1,6) = 64.3$, $p < .01$, but no interaction.

A median split was done on clustering scores in both the full and divided attention conditions to divide the subjects into a "low organizational processing" group and a "high organizational processing" group. Figure 7 shows the proportion of words recalled at each level of elaboration for the low and high organizational processing groups in both the full and divided attention conditions. Again, proportion recall was pooled across participants, and elaboration ratings of zero and one were collapsed together, as were ratings of five and six, due to the relatively few words given ratings at the extreme ends of the scale. As Figure 7 demonstrates, the relationship between elaboration rating and proportion recalled did not differ systematically between the low and high organization groups in the full attention condition. A two by five factorial analysis of pooled recall proportions from the full attention condition indicated that the main effect of level of organization was insignificant, $F(1, 4) = 0.46$, $p > .05$. The main effect of level of elaboration did not quite reach significance either, $F(4,4) = 3.83$, $p = 0.11$. 
In the divided attention condition, participants in the high organization group achieved higher levels of recall than participants in the low organization group at each level of elaboration, although their performance was still inferior to that achieved in the full attention condition (see figure 7). A two by five factorial analysis of pooled recall proportions from the divided attention condition revealed a significant main effect of both level of elaboration, $F(4,4) = 19.7, p < .01$, and level of organization, $F(1,4) = 16.7, p < .05$, but no interaction.

Based on these findings, no attempt was made to generate a function from the FA data, relating elaboration and organization to memory performance; it is clear that such a function would not accurately predict memory performance in the DA condition.

**Discussion**

E3 succeeded in its goal of producing a decline in memory performance while obtaining an adequate measure of both elaborative and organizational processes. Elaboration ratings correlated positively with proportion recalled in both the full and divided attention conditions, suggesting that the participant generated subjective ratings of E3 are a better measure of level of elaboration than the length of participant generated sentences, as used in E1 and E2. As predicted, the level of both organization and elaboration declined in the divided attention condition, compared with the full attention condition. In line with Craik’s (unpublished) data, even when level of elaboration was equated, memory performance in the divided attention condition remained inferior to performance in the full attention condition. Together, the results of the Craik experiment and E3 suggest that the effect of reduced processing resources on memory performance cannot be fully explained in terms of less extensive elaborative processing.
E3 went beyond Craik’s (unpublished) experiment by considering organizational processing in addition to elaborative processing. Unfortunately, the inclusion of organization as a factor did not shed much more light on the precise way in which reduced processing resources interferes with memory performance. Extent of organizational processing did not appear to have any influence on the probability of recall, separate from elaborative processing, in the full attention condition. In contrast, organization did appear to make a unique contribution to memory performance, above and beyond elaboration, in the divided attention condition. This suggests that extensive processing along multiple dimensions of encoding (i.e. both organization and elaboration) is not necessary for optimal memory performance under “normal” circumstances, but can increase memory performance under conditions where processing resources are reduced.

However, memory performance under divided attention conditions remained inferior to performance under full attention conditions even when both level of elaboration and level of organization were equated. Thus it appears that while the effects of reduced processing resources on memory performance cannot be fully explained by changes in elaboration and organizational processing alone, processing along multiple dimensions becomes more essential to effective encoding when processing resources are reduced.

**General Discussion**

The results of E1 and E2 demonstrated that memory performance declines under conditions of divided attention when encoding involves the generation of sentences from stimulus words, but not when encoding involves linking the generated sentences together into a story. These findings suggest that deficiencies in memory performance normally
associated with a reduction in available processing resources can be overcome by
orienting tasks which necessitate extensive elaborative and organizational processing.
The implication is that a reduction in processing resources does not preclude the deep,
elaborative and organizational processing necessary for effective encoding, but is perhaps
better characterized as a reduction in processing efficiency. In other words, the orienting
task may act to utilize available resources more efficiently than participants can on their
own, utilizing self-initiated learning operations. This conclusion is in line with
numerous other studies reporting that orienting tasks improve memory performance
under various conditions associated with reduced processing resources, including divided
attention (Craik & Byrd, 1982), intoxication (Hashtroudi, Parker, DeLisi, & Wyatt, 1985)
and older age (Perlmutter, 1978). The results of E1 are especially striking because the
negative effects of reduced processing resources were completely overcome by the
orienting task, such that all differences in memory performance between full and divided
attention conditions were eliminated.

The results of E1 and E2 do not speak directly to the main proposal motivating
the current research, that dividing attention interferes with memory performance by
producing qualitative changes in the depth, elaboration and organization of encoding.
However, support is provided for the necessary corollary proposal, that in order to
explain fully the main effect of encoding processes on subsequent memory performance,
it is necessary to take into account organization, as well as depth and elaboration of
encoding. If it is assumed that the important difference between the encoding tasks used
in E1 and E2 is the extent of organizational processing required, the results suggest that
organizational processing acts as a qualitative dimension of encoding distinct from depth
and elaboration, and that superior memory performance depends on extensive processing along all three dimensions. This conclusion is in line with Hunt and Einstein’s (1981) finding that participants who perform both individual item and relational orienting tasks exhibited superior memory performance compared to participants who performed only one type of orienting task, even when the same orienting task was performed twice.

The results of E3, however, suggest that extensive processing along both elaborative and organizational dimensions is not necessary for optimum memory performance under all conditions. When recall was examined across various levels of both organization and elaboration, it appeared that organization made a distinct contribution to memory, above and beyond elaboration, only in the divided attention condition, but not in the full attention condition. Thus it may be that extensive organizational processing was superfluous in the full attention condition of E1, but made a unique contribution to memory performance in the divided attention condition, thereby preventing the expected decrement in recall. If this hypothesis is correct, one would expect that level of organization (ARC scores) would be positively correlated with recall only in the divided attention condition, as was the case in E3. However, exactly the opposite was found in E1: ARC scores were positively correlated with recall only in the full attention condition. This suggests the intriguing alternative possibility that extensive elaborative, not organizational, processing was superfluous in the full attention condition of E1. In other words, memory performance in the full attention condition may have been supported mainly by the extent of organizational processing, while extensive elaborative processing made a unique contribution only in the divided attention condition, preventing the expected decline in memory performance.
How do Hunt and Einstein’s (1981) findings fit in with the above scenario? Their encoding tasks were carried out under full attention conditions, yet in contrast to the full attention condition of E3, it appeared that organizational processing did make a unique contribution to memory performance, above and beyond elaboration. The answer may lie in the differences between the orienting tasks used in the two experiments. As an elaborative encoding task, Hunt and Einstein had participants rate the pleasantness of target words, while in E3, participants were asked to generate a mental image in response to target words. Arguably, generating a mental image requires much more extensive elaborative processing than does rating the pleasantness words. Perhaps organization makes a distinct contribution to memory performance when elaborative processing is minimal, but not when elaborative processing is more extensive.

This hypothesis fits nicely with the finding of E3 that in the full attention condition, participants with high organization scores exhibited better memory performance than participants with low organization scores at the lowest levels of elaboration, and equivalent levels of recall at all other levels of elaboration (see Figure 7). In combination with Hunt and Einstein’s findings, the results of the current series of experiments therefore suggest that optimal memory performance requires extensive processing along only one dimension of encoding (organization or elaboration), but when either processing resources or extent of processing is reduced, memory performance benefits from processing along multiple dimensions of encoding (elaboration and organization).

It is tempting to conclude that reductions in available processing resources and reductions in the extent of processing are in effect the same thing. However, the results
of E3 challenge this conclusion. It is true that elaborative and organizational processing were found to be less extensive in the divided attention condition of E3, but when the extent of both elaboration and organization was equated, participants in the divided attention condition still exhibited a decrement in memory performance. This finding challenges the proposal that the detrimental effect of reduced processing resources on subsequent memory performance can be fully explained in terms of qualitative changes in the depth, elaboration and organization of encoding processes. One possibility is that because organization was measured at the time of recall, the extent of organizational processing that occurred at encoding was not accurately represented. If in the divided attention condition the majority of organizational processing occurred at the time of retrieval, it is possible that a measurement of organization which was taken at the time of encoding might have more accurately predicted later recall. Further research in which organization is measured at encoding is needed to eliminate this possibility. A second possible interpretation of these results is that a reduction in processing resources interferes with yet another distinct, qualitative dimension of encoding processes beyond depth, elaboration and organization. However, it is not at all obvious what that additional dimension might be. As the previous discussion demonstrates, it appears that even organization does not always make a unique contribution to memory performance, above and beyond elaboration and depth.

A third possibility, suggested by Craik (1983), is that in addition to interfering with encoding processes, reduced processing resources also interfere with a consolidation process that occurs between encoding and retrieval. Craik further suggests that this consolidation process may have no overt behavioral correlate, and is only observable at
the neurological level. It is not clear, however, what the temporal characteristics of such a consolidation process would be. For example, how soon after a stimulus has been encoded does consolidation of the memory trace begin? Can encoding and consolidation overlap temporally? What is the duration of consolidation? At the very least, tentative answers to these questions are needed before the effects of reduced processing resources on consolidation can be examined.

Very few attempts have yet been made to investigate the effects of divided attention on memory processes at the neurological level. One exception is an ERP (event-related potential) study conducted by Mangels, Picton and Craik (1998), which examined the effects of divided attention on episodic encoding. Memory performance was tested both by free recall, and by a recognition task in which participants were asked to indicate whether they explicitly “remembered” encoding the item, merely “knew” that they had previously encoded the item, or did not recognize the item. Their results suggest that episodic encoding is a multi-stage process including an early, phasic process occurring 250-400 ms after stimulus onset, and a subsequent sustained process occurring between 400 and 750 ms. The early process was found to differentiate recalled and missed items, but did not distinguish between “remembered” and “known” items. Mangels, et al therefore proposed that the early process is related to conceptual stimulus analysis and results in an uncontextualized memory trace capable only of supporting familiarity-based retrieval. In contrast, the later process differentiated “remember” and “know” responses, but did not distinguish recalled from missed items, and is proposed to support the elaboration and contextualization of the early memory trace necessary for conscious recollection. Encoding condition (full versus divided) was found to modulate both early
and late processes. No interaction was found between encoding condition and memory effects, suggesting that reduced processing resources do not change the nature of neurological processes involved in encoding, but simply reduce the likelihood that those processes will be successfully completed.

The results of the Mangels et al (1998) study suggest another interpretation of the findings of E3. Perhaps it is possible for extensive elaborative processing to occur even when early (250-400 ms) encoding processes have been compromised, and that when this occurs, memory performance falls short of what would otherwise be predicted based on elaborative processing alone. Thus even when elaborative processing is equated, one would expect memory performance to be lower under divided attention conditions, because early encoding processes are more likely to have been compromised. However, this proposition is rather counterintuitive. It seems that successful early processing would be a necessary prerequisite to subsequent extensive, elaborative processing. Furthermore, the results of Mangels et al (1998) suggest that divided attention manipulations are more likely to affect later, elaborative processes than early processes. Similarly, behavioral research suggests that divided attention does not affect the “familiarity” component of recollection, which is presumably supported by early processes (Jacoby, Woloshyn, & Kelley, 1989).

One final possibility, also related to the Mangels et al (1998) study, is that the proportion of “remembered” and “known” items contributing to the total number recalled at each level of elaboration differs between full and divided attention conditions. Given the Mangels et al finding that the later (400-750 ms) encoding process, proposed to support elaboration, predicts “remember” (R) responses better than “know” (K).
responses, it would not be surprising if a change in relative proportion of the two kinds of responses at each level of elaboration also changed the curve relating elaboration to memory performance. Mangels et al report that the relative proportion of R and K responses does in fact change in the divided attention condition: while the number of R responses decreases, the number of K responses remains the same, resulting in a larger proportion of K responses. Parkin and Walter (1992) demonstrated that the proportion of K responses also increases with old age, another condition associated with reduced processing resources. However it is not clear how the relative proportions of R and K responses would change across different levels of elaboration under either full or divided attention. Furthermore, if under divided attention conditions, the proportion of K responses was found to increase at each level of elaboration, thereby providing a possible explanation for the finding that elaboration does not accurately predict recall when attention is divided, the question remains: why does extensive elaboration not support high proportions of R responses under divided attention?

In conclusion, the present series of experiments has raised more questions than it has answered. The inclusion of organizational processing in the analysis did not significantly contribute to our understanding of how reduced processing resources interferes with memory performance. Instead, the current evidence points to the conclusion that a reduction in resources affects more than just elaborative and organizational processing, possibly interfering with pre-elaborative, post-elaborative or simultaneously occurring processes as well. Additional research, at both the psychological and neurological level, is needed to further explore the nature of these
processes, under both “normal” conditions, and those where processing resources are compromised.

On a more positive note, the current series of experiments did contribute to our understanding of how decrements in memory performance attributable to reductions in available processing resources can be ameliorated. Specifically, the results suggest that orienting tasks which can encourage extensive processing along more than one dimension of encoding (i.e. both organization and elaboration) are especially effective at “propping up” recall performance at or near optimal levels. Findings such as these are particularly interesting within the context of aging, where an understanding of how to minimize the negative effects of advanced age on memory performance can make meaningful contributions to older adults’ quality of life.
References


### Table 1

**E1-E3: Recall, Elaboration and Organization**

<table>
<thead>
<tr>
<th>Attention</th>
<th>Experiment 1</th>
<th></th>
<th>Experiment 2</th>
<th></th>
<th>Experiment 3</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Full</td>
<td>Divided</td>
<td>Full</td>
<td>Divided</td>
<td>Full</td>
<td>Divided</td>
</tr>
<tr>
<td>Mean Prop. Recall</td>
<td>0.61</td>
<td>0.63</td>
<td>0.45</td>
<td>0.35</td>
<td>0.61</td>
<td>0.35</td>
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<tr>
<td>Mean Elaboration</td>
<td>11.33&lt;sup&gt;e&lt;/sup&gt;</td>
<td>10.06&lt;sup&gt;e&lt;/sup&gt;</td>
<td>11.26&lt;sup&gt;e&lt;/sup&gt;</td>
<td>9.39&lt;sup&gt;a,e&lt;/sup&gt;</td>
<td>3.5&lt;sup&gt;f&lt;/sup&gt;</td>
<td>2.9&lt;sup&gt;b,f&lt;/sup&gt;</td>
</tr>
<tr>
<td>Mean ARC score</td>
<td>0.58</td>
<td>0.67</td>
<td>N/A</td>
<td>N/A</td>
<td>0.65</td>
<td>0.50</td>
</tr>
<tr>
<td>Correlation:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elaboration X Recall</td>
<td>-0.34</td>
<td>-0.11</td>
<td>0.25</td>
<td>0.11</td>
<td>0.44&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.46&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>ARC score X Recall</td>
<td>0.63&lt;sup&gt;d&lt;/sup&gt;</td>
<td>-.01</td>
<td>N/A</td>
<td>N/A</td>
<td>-0.03</td>
<td>0.24&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Mean Performance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>on Secondary Task</td>
<td>N/A</td>
<td>.58&lt;sup&gt;g&lt;/sup&gt;</td>
<td>N/A</td>
<td>.60&lt;sup&gt;g&lt;/sup&gt;</td>
<td>N/A</td>
<td>.75&lt;sup&gt;g&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a</sup>Denotes a significant difference between full and divided attention conditions at \( p < .05 \).

<sup>b</sup>Denotes a significant difference between full and divided attention conditions at \( p < .01 \).

<sup>c</sup>Denotes a significant correlation at \( p < .05 \).

<sup>d</sup>Denotes a significant correlation at \( p < .01 \).

<sup>e</sup>Elaboration measured by length of sentences generated by participant.

<sup>f</sup>Elaboration measured by subjective rating generated by participant.

<sup>g</sup>Proportion of target sequences correctly detected.
Figure Captions

**Figure 1.** Experiment 1: Memory performance (proportion recalled) as a function of organization (ARC score) under full and divided attention.

**Figure 2.** Experiment 1: Memory performance (proportion recalled) as a function of mean sentence length (words per sentence) under full and divided attention.

**Figure 3.** Experiment 2: Memory performance (proportion recalled) as a function of mean sentence length (words per sentence) under full and divided attention.

**Figure 4.** Experiment 3: Memory performance (proportion recalled) as a function of mean elaboration (subjective rating).

**Figure 5.** Experiment 3: Memory performance (proportion recalled) as a function of organization (ARC score).

**Figure 6.** Experiment 3: Memory performance (proportion recalled, pooled across participants) as a function of level of elaboration (subjective rating).

**Figure 7.** Experiment 3: Memory performance (proportion recalled, pooled across participants) as a function of level of elaboration (subjective rating) and level of organization (high or low ARC score).
Figure 1.

Proportion Recall vs. Clustering Score (ARC)

- **Full Attention**
- **Divided Attention**
- **Linear (Full Attention)**
- **Linear (Divided Attention)**
Figure 2.
Figure 3.

![Graph showing the relationship between mean sentence length and proportion recall](image-url)
Figure 4.
Figure 5.
Figure 6.
Figure 7.

![Graph showing the relationship between elaboration rating and proportion recall (pooled across subjects). The graph compares FA - High Org., FA - Low Org., DA - High Org., and DA - Low Org.]