

Memory Performance as a Function of Stimulus Input Characteristics
for both Aphasic and Normal Adults

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Historical Overview. Previous investigations have described methods of evaluating storage, retention and retrieval processes for short term memory (STM) in normal subjects (Murdock, 1961; Postman and Phillips, 1965; and Rundus, 1971). These researchers attempted to measure the characteristics of STM storage systems by observing free recall responses to serial word lists. These authors recorded the chance that a word would be recalled as a function of each word's position in the list. Murdock (1961), for example, demonstrated a pattern of responses by serial position for 19 normal subjects' free recall of 30 unrelated words presented at the rate of one word per second. This procedure was repeated 80 times over a four-day period. His results indicated that free recall was extremely accurate for both the beginning of the word list (primacy effect) and the end of the list (recency effect), but that accuracy was relatively low near the middle of the list. This serial position curve for free recall seems to reflect two distinct memory systems. Based on these observations, Murdock theorized that the latter part of the curve (representing the recency effect) delineates STM while the initial part of the curve reflects the retrieval of information from long term memory (LTM) storage. Later, Murdock (1962) expanded this hypothesis by demonstrating, with normal subjects, that as the rate of the words presented was decreased (allowing two seconds on each word rather than one) performance for the STM portion of the curve (recency) did not change. However, improvement on the LTM portion of the curve was noted. Murdock concluded that allowing normal subjects added time for rehearsal (thus getting more information into LTM) will significantly improve performance while STM operations appear to be unaffected. Rundus and Atkinson (1970) and Rundus (1971) corroborated Murdock's results. These investigators demonstrated that early words in lists are rehearsed more than later words (for normal subjects) and this results in improved recall performance for initial versus middle items. It has also been demonstrated that earlier words in a list tend to be encoded in terms of their meaning, suggesting long term memory storage (Smith, Barresi and Gross, 1971; Mazuryk, 1974; Kosslyn, Holyoak and Huffman, 1976). Implicit in the design of these investigations is the assumption that memory is influenced by units of information and various aspects of time, such as stimulus on-time, between-stimulus interval, latency of response, etc. However, these investigations did not consider linguistic attributes of the stimuli.

Although a considerable body of knowledge exists describing various aspects of memory, relatively few investigations in speech and language pathology have been concerned with the impact of serial position upon memory performance following brain injury. There are some observations in recent literature that begin to point toward the importance of estimating the functional integrity of both the STM and LTM systems. Locke and Deck (1978) have been interested in retrieval failure and STM loss in aphasic adults. They presented five aphasic patients with three pictures and then

turned the pictures over. The patients were then presented with the target picture and required to turn up the matching picture. Results indicated that initial (primacy) and final (recency) items in the lists were recalled with more accuracy compared to middle items when initial items were made nameable. Locke concluded that the presence of a recency/primacy effect was evident for left-brain-damaged adults. In a serial position experiment with one aphasic adult, Saffran and Marin (1975) demonstrated the presence of a recency-primacy effect for digits presented auditorally and visually. In addition, these authors concluded that abnormal STM performance for their subject had little effect on LTM retention when digits were presented only auditorally. Albert (1976) demonstrated a significant deficiency in auditory STM for aphasic adults. Heilman, Scholes and Watson (1976) suggested that similar STM deficiencies are seen in various forms of aphasia. None of these previous investigations have controlled the linguistic attributes of stimuli or utilized a control group. These previous investigations suggest that various input factors, such as stimulus exposure duration, stimulus interval duration, stimulus familiarity, and rehearsal ability may affect memory processing (the serial position curve). It appears reasonable to assume that differing linguistic categories carrying different syntactic and semantic loads might also affect the serial position curve.

The purpose of this investigation was to study the relationship between linguistic stimuli and memory as reflected in the serial position curve. The following question was asked. What are the effects of differing linguistic stimulus characteristics upon the serial position curve derived from the free recall performance of brain-damaged and normal subjects?

Subjects. Subjects for this investigation were 10 left-brain-damaged aphasic and 10 normal adults. All subjects in the left-brain-damaged group met the following selection criteria. Each subject was at or above the 50th percentile on the Porch Index of Communicative Ability (PICA, Porch, 1967), each subject had left brain damage as confirmed by three of the following four procedures--abnormal angiogram, abnormal motor signs, abnormal CAT scan, or abnormal brain scan. Any subject who exhibited right hemisphere brain damage was excluded from the study. Additionally, each aphasic subject showed no worse than a 30 dB HL hearing level and had sufficient understanding and ability to perform the experimental task, as measured by 100% accuracy on pretrial testing. Finally, all aphasic subjects were at least six months post onset of aphasia.

All subjects included in the normal group met the following criteria. Each subject had no worse than a 30 dB HL hearing level, each had sufficient ability to perform the memory task as measured by 100% accuracy on pretrial testing, and none had a history of neurological disability.

Experimental Conditions and Stimuli. Three experimental lists were presented. The lists were comprised of 1) one list of 12 nouns, 2) one list of 12 verbs, and 3) one list of 4 nouns plus 4 verbs plus 4 nouns. These three lists of 12 randomized words were randomly presented to each subject.

The stimuli for this investigation were 36 words taken from the Thorndike Word List (400A). Each set of 12 words (all nouns; all verbs; and 4 nouns plus 4 verbs plus 4 nouns) was randomly assigned to the appropriate list type for each subject studied. Each word was matched with a corresponding picture taken from the Peabody Language Development Kit (1966). Each stimulus was presented with a simultaneous visual and auditory exposure duration of 1.5 seconds.

Apparatus and Experimental Procedure. All procedures were carried out in a sound-treated room to minimize environmental noise and to maintain constant experimental conditions for all subjects. Within the room was a two-channel tachistoscope and a reel-to-reel tape recorder which were used to present the visual and auditory experimental stimuli.

All subjects, after meeting criterion standard, were randomly presented with the three experimental word lists. After the random presentation of each list of 12 words, each subject was required to recall verbally as many items as he or she could. After a two-minute recall interval, the patient was instructed to tap 25 times on an index finger oscillator. All subject responses were taped and graphically recorded. This procedure continued for all word lists and remained constant for all subjects studied.

Results. Results were analyzed in order to determine differences between groups, list types, and serial position. The statistical analysis involved a 3 x 2 x 2 Analysis of Variance Procedure with repeated measures. Table 1 summarizes the results for all subjects studied. Statistically significant ($P < .01$) differences were noted between groups for each of three serial positions, and for the interaction of list type and serial position.

Table 1. Summary of analysis of variance results for groups, list types and serial positions.

<u>FACTORS</u>	<u>TOTAL PROBABILITY</u>
Groups	.0001
List Type	.0779
Serial Position	.0002
List Type x Position	.0004
List Type x Group	.0673
Serial Position x Group	.0730
Groups x List Type x Serial Position	.6452

Figure 1 summarizes total recall differences for each group according to serial position for nouns. The normal group recalled 37 items in the initial, 17 medial and 37 items in the final position, with 54 items recalled in the primacy portion of the curve. The pathologic group recalled 14 items in the initial, 9 in the medial and 23 items in the final position with 23 total items recalled for the primacy portion. Figure 2 shows a similar pattern of performance for both groups with lists of verbs. In this condition, the normal group recalled 40 items initial in initial position, 21 items in the medial and 35 items in the final position. The primacy portion of the curve was estimated with 61 items recalled. The aphasic group recalled 18 initial, 7 medial and 25 final items, with 25 total items for the primacy portion of this curve.

As seen in Figure 3, the pattern of recall performance was quite dissimilar for both groups in the noun plus verb plus noun condition. Here, the normal group recalled 26 initial items, 26 medial items and 26 final items with 52 items recalled in the primacy area. The aphasic group recalled 13 initial, 17 medial and 19 final items with a total of 30 items recalled in the primacy position. Figure 4 summarizes the results of the average recall performance between serial position and the differing list types for all subjects studied.

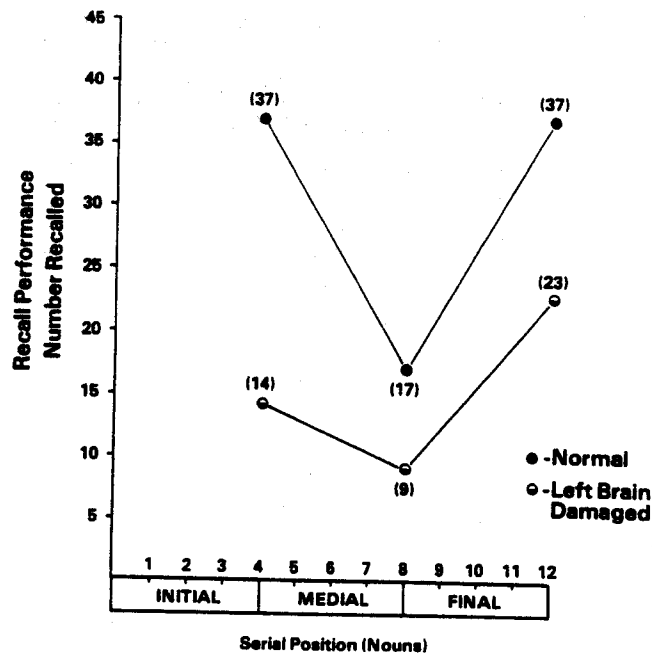


Figure 1. Total recall of each group for nouns by serial position.

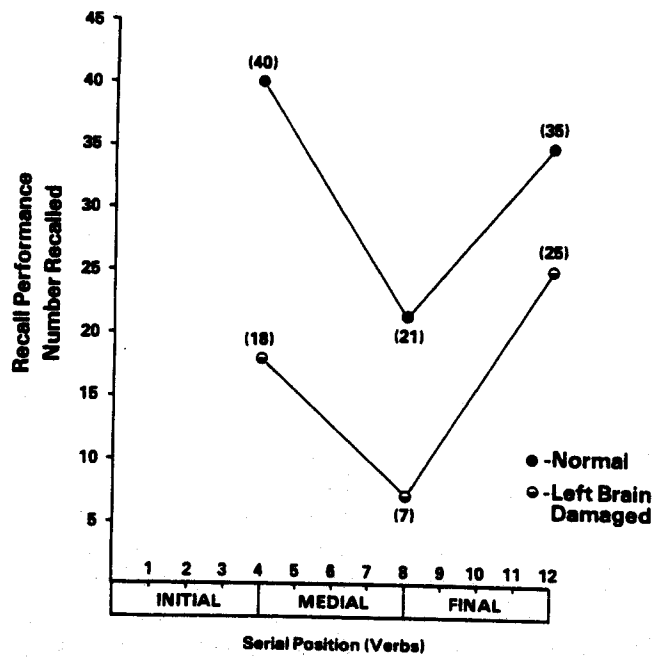


Figure 2. Total recall of each group for verbs by serial position.

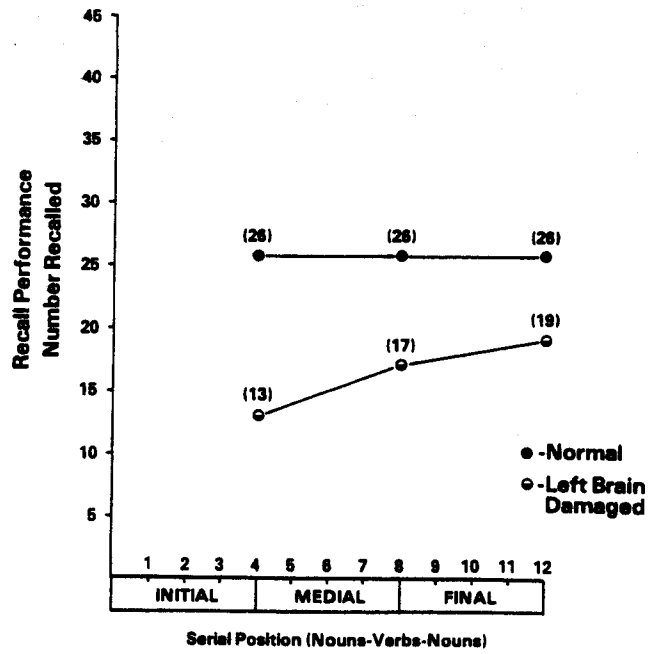


Figure 3. Total recall of each group for nouns-verbs-nouns by serial position.

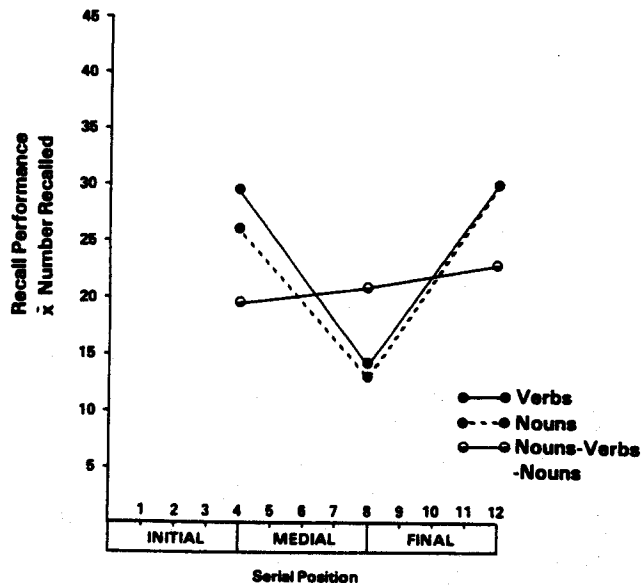


Figure 4. Combined recall results for serial position and word list type.

Conclusions. Based on the results of this experiment, it was concluded that a recency/primacy effect was evident for lists of nouns and verbs for all subjects studied. However, this effect was significantly disrupted in the nouns condition and in the verbs plus nouns condition. In the latter condition, there was a noticeable decrease in recall performance for initial and final words in the list, while recall for medial items increased. This resulted in an absence of both a recency and primacy effect. Middle items (verbs) were more often recalled than middle items in any other list condition for both groups studied. Additionally, the results for this list showed a decrease in total recall performance across serial position for the normal group (N=98, V=96, N+V+N=78). It appeared that N+V+N condition interfered with the normal group's total recall for both the LTM (first eight items) and STM (last four items) portions of the serial position curve. The aphasic group, on the other hand, demonstrated best LTM retrieval within this condition, with a substantial increase in middle items recalled (+8 from nouns; +10 from verbs). However, the final nouns in this list condition were most poorly recalled by the aphasic group, indicating that while LTM processing improved, STM processing suffered. These findings appear to indicate that the middle items (verbs) in the list took precedence over the initial items (nouns) already in LTM, as demonstrated by significant decreases in initial vs middle items in this list condition for both groups studied. In addition, there was noticeable decrease in recall for the STM portion of this list for all subjects. This finding indicates that verbs, in addition to overriding initial units of information in LTM, took priority over the final items, resulting in sacrifice of STM retrieval to LTM processing strategies. These results appear to support previous research (Smith, Barresi and Gross, 1971; Mazuryk, 1974; Kosslyn, Holyoak and Huffman, 1976) which suggest that earlier words in a list tend to be encoded in terms of their meaning. Because language and memory have been postulated to be a function of the internal structure of verbs, rather than the surface structure on noun elements, these findings may suggest that the verbs in the middle position in noun plus verb plus noun condition were selected by all subjects over the noun elements for more meaningful processing activity.

The results of this study for total recall across serial position demonstrated that the verb list was best recalled by all subjects studied. Nouns were second, followed by the list of nouns plus verbs plus nouns for the normal group. The pathologic group demonstrated an inversion of the normal group's results for list of nouns and nouns plus verbs plus nouns. Both groups' recall performance elicited similar patterns of results for all experimental list conditions except with respect to the level of performance. This finding seems to suggest decreased LTM and STM abilities for the aphasic group.

These findings appear to have clinical implications for facilitation of memory and recall for some aphasic adults. By describing and specifying specific stimulus attributes, LTM processing for some patients may be facilitated. Emphasis on verbs may elicit more appropriate LTM and STM performance by aphasic adults. A short screening procedure involving evaluation of memory and learning efficiency may be useful in determining the most appropriate stimulus materials for language-based treatment programs.

The present research findings appear to be only the beginning in an area that needs further study. In our hospital setting, we are presently examining recall for differing word list combinations with various classes of words, modes of stimulation, and types of aphasia. Subsequent research

might examine recall focusing on verbs plus nouns plus verbs. This would assure that the effects of negating the recency/primacy effect in this investigation were not based on nonspecific changes within a word list.

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DISCUSSION

- Q: How long must a list be before you can look at long term and short term memory?
- A: Early work of Murdock suggests that lists can range from 10 to 40 items. What you look for are the patterns of recall based upon the serial position curve. Murdock found that number of items and rate of presentation did not affect the patterns of response for normal subjects.
- Q? What would be the influence of reaction time data in this experiment?
- A: As stated in the text of this paper, recall performance was our primary

interest; however, reaction time data would add another dimension to a study such as this and would, in my opinion, be interesting to investigate.

- Q: Have there been investigations reported on free recall for verbs versus nouns?
- A: Not that I found. I did, however, in a review of literature come across this nouns versus verbs dichotomy in the repeated learning literature but not for free recall.
- Q: How did the patients respond in this investigation?
- A: The patients were instructed to verbally recall as many items as he or she could.
- Q: Did the degree of aphasia interfere with the ability to do this task?
- A: No, each subject was pretested to assure his or her ability to perform this task. Each patient was given a noun and verb, both auditorally and visually, asked to wait 15 seconds, then recall each item.
- Q: Did you pretest them on all the nouns and verbs used in this study?
- A: No, we randomly selected one noun and one verb from a list and neither word was used again in the experiment.
- Q: Were the patterns of recall you reported representative of individual patterns of each subject?
- A: Yes, I feel that the patterns for the groups reported do represent individual patterns for each subject. As a result of this, a clear group pattern for both normals and pathologies emerged.
- Q: How can you attribute the recall performances seen in this experiment to be only a memory problem rather than an aphasic disorder?
- A: I never stated in the text of this paper or in discussion that these individuals suffered only from memory impairment. What I did state was that aphasic patients seem to have memory processing problems. This can be seen as being different from normal performance on a task, such as the one reported here today.