Intraserial Repetition Effects upon Levels of Cognitive Processing

by

Richard E. Cordes

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APPROVED:

Lawrence C. Perlmuter, Chairman

Jerald F. Kehoe

James D. Fritzen

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Redundant information is a copy of previously transmitted or received information, (Miller, 1953). Since redundancy is common in everyday life (e.g. the number of 55 mph speed limit signs on an inter-state) it is important to understand the effects repeated information may have on a given task. The particular focus of this study is to determine the effects repetition may have if the task requires searching a number of items according to a rule (e.g. what was the slowest speed limit sign?).

In this study a subject was given a rule or task involving the alphabetical ordering or comparison of a set of letters. If one of the letters in the set was a repeat of another member, how will the repetition affect response latency?

Probe Recognition Task

A task frequently used in studying the effects of intraserial repetition (repetition occurring within a series or set) was developed by Sternberg (1966, 1967). In Sternberg's probe recognition task a subject was required to indicate (yes or no) whether a presented item, termed the probe stimulus, was a member of a memorized set called the positive set. A probe stimulus occurring in a set that was not presented is said to be a member of the negative set. The reaction time (RT) was found to increase linearly with the size of the positive set, indicating the scanning or search must be serial in nature (each item searched one at a time). Similar slopes across set size for both positive and negative responses suggested the scanning was also exhaustive (every item was searched).

Morin, Konick, and Hoving (1973) studied the effects of repetition using a probe recognition task. A stimulus set of two, three, or four sequentially presented stimuli (digits) were shown followed by a ready signal and then a probe digit. On a number of trials a digit in the stimulus set was repeated one or two times, either at the beginning or end of the set. It was found that RT for nonrepeated probe items increased linearly with the number of nonredundant items, whereas increasing set size with a redundant item had no influence upon RT. For example, the numbers 3338, 3388, 338, and 38 all produced similar latencies. Morin et al. argued that this effect was caused by the reduction of redundant stimulus information. The subject upon presentation of redundant stimulus information would transform the set containing redundancy into a smaller set (e.g. 338 is reduced to 38). Processing would then continue using the reduced set which results in relative facilitation of the RT. While proposing the existense of a transforming operation, the experimenters did not allude to how the transformation operates or when (during processing) the transformation occurs.

The explanation proposed by Morin et al. (1973) is intuitively appealing in its simplicity, however, it cannot account for all of their data. In the same study the experimenters found a 15 to 25 msec faster RT ($p<.01$) for trials containing repeats of a single digit when the probe was a repeated item as compared to probed nonrepeated items. Similarly, Baddeley and Ecob (1973) using the Sternberg paradigm found significantly faster recognition when the probe was repeated in the set, than when the probe item was not repeated. In lists that contained repetition, the nonrepeated probe produced latencies that were no different from the probe in lists that contained no repetition.

The findings (Baddeley & Ecob, 1973) that repeated probe items are reacted to faster than nonrepeated probe items is not deducible from Sternberg's exhaustive scan model. Sternberg (1975) discussed Baddeley and Ecob (1973) trace strength interpretations and alluded to the possibility that repeated probes may increase the strength of an "internal signal" which facilitates RT at a binary decision stage (yes or no). However Sternberg dismissed this interpretation as too flexible and not subject to quantitative tests.

Probeless Memory Search Task

Perlmuter & Lively (1976) developed a unique probeless memory search task which was employed in the present study. The task was similar to the Sternberg paradigm in that it involved a cognitive search of a previously defined stimulus set. A subject was first shown a stimulus set which was immediately followed by a command. The command informed the subject of the task requirements. In their experiment the following three commands were used; Recite - recite the stimulus set as it was presented; Identify - find the first letter alphabetically that was in the set; and Reorganize - reorganize the stimulus set in alphabetical order. Latency was measured from the onset of the command until the subject responded with the first or single letter. The independent variables in this experiment were the three commands, set size (2 or 4 letters), intermember distance (letters were separated alphabetically by 0, 1, or 2 letters), target set (correct response was either in the range A-E or F-J) and trial blocks.

Results showed that RT increased linearly with the number of letters in the stimulus set for all three commands. The reorganize task produced a slower RT and steeper slope as set size increased, than the less difficult task of identification. The recite task resulted in the fastest RT and produced the most horizontal slope across set size. The slope across set size tended to decrease as intermember distance increased under the recite and identify tasks, but increased under the reorganize task. For all three commands RT was longer for items from the F-J target set than for the A-E set.

Two theoretical positions were proposed to account for the results, (Perlmuter & Lively, 1976). The first, a comparison model developed by Moyer and Landauer (1967) suggests that subjects compare constructed analogues of the stimuli. In this case the analogue represents alphabetical "size" or distance in the alphabetical sequence. The analogues of the letters are then internally compared with each other until the smallest analogue is found. The smallest analogue is thus the first letter of the alphabet in the given set. Each letter must be compared with each other letter resulting in _n-1_ comparisons. Alternatively, Parkman (1971) proposed a different model which is not based on internal comparisons but rather on external comparisons involving an alphabetically ordered list. In this model (termed the same-different model) a subject would start early in the alphabetical sequence and proceed serially in the sequence until a match is found. The match would thus have to be the first alphabetical letter in the set.

Lively & Perlmuter (1976) devised an experiment to determine which of the two models (comparative-judgement vs. same-different) was more viable. It was hypothesized that if the comparative-judgement model was tenable then partial advanced information of where the target lies in the alphabet would reside outside of the internal comparison processes. In this manner RT would be affected by the intercept of the set size function and not the slope. In contrast the same-different model would only affect the slope, since partial advanced information should reduce the number of comparison cycles required. Results revealed that only the intercept was affected, thus lending support to the comparative-judgement model.

Stage Analysis

The focus of this paper will not concern stage analysis since the probeless memory search task has not reached sufficient theoretical development for this type of endeavor. However, references to stages and some stage analysis will be attempted at a very rudimentry level. It is for this reason the following methods of stage analysis are introduced.

Donders (1969) in 1868 originated a subtractive method for the decomposition of RT into component stages. If it is assumed that response *A* contains one more processing stage than response *B*, then the resulting difference between the latencies of the two responses should give an indication of the duration of the additional stage.

More recently Sternberg (1969a, 1969b) developed the additive factor method which was used to separate and test proposed cognitive stages. Assessment of RTs by analysis of variance suggested that if two or more independent variables interact, then they are presumably affecting the same processing stage. Different processing stages are thought to be affected if the effects are additive without interaction.

Through the use of the additive factor method, Sternberg (1969b) was able to decompose RT in the memory search task into the following four basic stages. They are: 1) stimulus encoding; 2) serial comparison; 3) binary decision; and 4) translation and response organization. There is concern that the successive stages might overlap in time (e.g. Smith, 1968) and that failure to obtain an interaction may not prove the independence of proposed stages (Taylor, 1976). However, with due consideration towards these criticisms, the additive factor method represents an ingenuous and perhaps the best method of stage analysis developed.

Theoretical Development

A question underlying possible explanation of the repetition effect is one of determining how repetition is represented in memory. Howell (1973), in a review of the possible theories on the representation of repeated events, identified four views; the trace-strength hypothesis, the multiple-trace hypothesis, the multiple-process hypothesis, and counting.

According to the trace-strength hypothesis an event is identified by an internal process which grows stronger with each successive occurrence of the event. All that is available is the current strength value representing the number of occurrences of an event. Due to its cumulative nature all individual representations are lost. In recognition it is assumed that a subject compares the trace strength of the test item with a criterion or decision rule, (Norman & Wickelgren, 1969). If the strength of the test item exceeds the strength of the criterion a "yes" is given, otherwise the response is "no". When the strength of the test item approaches the criterion it is assumed that the decision is more difficult thereby leading to longer RTs.

A more elaborate version of the trace-strength hypothesis was presented by Baddeley and Ecob (1973). In their model the presentation of the probe directs the subject to the proper memory location presumably through a matching process. However, the operation of this process is not elaborated. Based upon the trace strength of the item, the subject indicates whether the probe was in the set. The more familiar (the stronger the trace) probe item will result in faster selection and shorter RT. Baddeley and Ecob (1973) assumed that only a fixed amount of trace strength is divided among each member of the positive set. If the number of items in the set is not known in advance (which is true in most cases) then how can each item receive a proportion of the available trace strength when that proportion is based upon the total number of items? What must occur (and is not stated explicitly) is with each increase in the number of items another division is performed which will produce an equal amount of trace strength for each item based upon the new number of items. This implies that all the trace strength available is deposited with the first item and then divided with additional items. Thus as set size increases, the amount of trace strength available for a single item decreases. Quantitatively then $T=C/N$, where T is the average amount of trace strength available per item, C is the fixed amount of trace strength available, and N is the number of items in the set. Increasing the number of items would result in a reduction in the differences between the average strengths of the positive and negative items (C/N and 0 respectively), making discrimination between these sets more difficult. Baddeley and Ecob (1973) state that each letter set or sequence has a neutral point (with respect to the positive and negative sets) defined as the point half way between the mean trace strength of the positive and negative sets. Decision time is assumed to be proportional to the inverse of the difference between the average item's trace strength and the neutral point. The neutral point approaches zero as set size increases. This assumption explains the set size effects empirically found for the negative set. Since the average trace strength is zero for an item from the negative set, decision time becomes the inverse of the neutral point. Thus, when the neutral point is small, due to a large set size, decision time is increased. The neutral point is assumed to always be at the half way point in order to account for the parallel and linear RT function with set size. The elaboration of the trace strength model by Baddeley and Ecob (1973) was developed in an attempt to explain the effects of repetition in a more parsimonious fashion without the use of both a search and a strength model. However, the elaboration does not change the trace strength model's prediction that a repeated item will be reacted to faster because it possesses a larger proportion of the available trace strength.

There are other alternatives for frequency representation that Howell (1973) presented. One is the <u>multiple-trace hypothesis</u> which states that repeated occurrences of an event are represented by separate traces which coexist, and are distinguishable by a "tagged" attribute. The tagged attribute would most likely be a temporal "marker" however, tagging of modalities of input is also possible (Hintzman, Block, and Inskeep, 1972). In this manner the number of stored traces would represent the frequency of an event rather than one cumulative memory trace. Another view representing a compromise between the trace strength and multiple trace hypothesis is called the multiple process hypothesis. In this model trace strength and the number of occurrences of an event are represented together in memory (Underwood, 1969a). Another possibility of representing the frequency of an event is that a subject can simply count the number of occurrences.

In Howell's multiple-trace and counting hypotheses it is theoretically possible for an event to be recalled independently of the retention of the events frequency. It may be assumed that the memory trace of an event is not affected by the frequency of the event (Underwood, 1969b). Although this assumption has been questioned (Howell, 1973), if the independence were true then its effects would not be congruent with those predicted by trace strength models.

If independence or partial independence between the representation of an item and its frequency were assumed then repetition would have negligible affects upon the retrieval of an item. However, set size would be reduced (since repeated items are used for frequency representation) resulting in a smaller number of items to search. This of course would reduce latency. Morin, Konick, and Hoving (1973) used the term "reduction of redundant information" to describe this process. However, since the use of repetition reduces the information available in a set or list, this paper will refer to the process as an information reduction model. The essential features of the model are; 1) repeated items are processed according to one of the non-trace strength models previously described, and 2) the RT of the search or comparisons of the items in a stimulus set is equal to the duration of the processing of the unique (non-redundant) stimulus information.

DeRosa (1969) has shown that subjects can edit memory sets. A positive set of four different items was followed by a deletion set. Part of the subject's task was to remove the deletion set from the positive set. A probe item was then presented. The subject was to respond positively if the probe was in the set of items which remained positive or negatively otherwise. Results have shown that subjects can reliably perform the editing task. Since subjects can perform this type of operation when requested, it is probably true that similar reduction processes may occur as a method of decreasing processing time. However it should be pointed out that in the DeRosa (1969) experiment the editing was an intentional act whereas information reduction as previously introduced may not be under conscious control.

According to the trace strength model, the stronger the strength value for an item the faster it can be recognized (Norman & Wickelgren, 1969). However, trace strength decreases over time, because of decay (Brown, 1958; Peterson & Peterson, 1959), interference or displacement (Waugh & Norman, 1965). Thus, an important consideration may be the order in which letters are retrieved during the comparison process. If the target letter was retrieved, only for the last comparison, its trace strength may not be as strong (had more time to decay or succumb to interference from other comparisons) than if it was retrieved first. During the comparison process the target item would have to be retrieved and maintained for each comparison performed since it is the "winner" of each pairwise comparison. This form of rehearsal may serve to maintain the integrity of the item's strength (Waugh & Norman, 1965).

As suggested by Hintzman (1974), repetition may act like italicized letters creating a Von Restorff effect (see Wallace, 1965 for a review, and Lively, 1972). The perceptual isolation of adjacent repetitions may serve as a marker for the subject to begin comparisons with the repeated letters. If a subject consistently chose repeated items for the initial comparison then RT may be facilitated not only because the item was repeated (initially possessing more strength) but also because the item was rehearsed more than the target items of control conditions. Likewise, if a subject always initially chose nonrepeated items for comparison then the effects of repetition may be weakened.

Perhaps rehearsal determines the effects of repetition more so than the assumed increase in trace strength of the repeated item. If the repetition was not perceptually distinct (e.g. IJKI) then the above model would predict no repetition effects since the probability of retrieving the repeated item first is not as high as when the item and repeat are adjacent (e.g. IIJK). Similarly it may be the case within the trace strength model that the amount of increase in trace strength resulting from repetition may be a function of the physical proximity of the item and its repeat. In this manner the trace strength and rehearsal models make almost identical predictions.

Coding Variability

The comparative-judgement and same-different models do not make different predications in this experiment. However, various strategies of coding or processing would greatly influence the results. In the probeless memory search task there are a number of methods of coding (hereby referring to the processes occurring during stimulus presentation) that a subject may use or acquire. Following is a list of possible coding strategies. 1) There may exist a one-to-one correspondence with the presented physical stimuli and the memory set, with no changing or editing (preprocessing) of the material. This is similar to the direct copy hypothesis which states that encoding produces an unprocessed direct copy of the presented stimulus (Sternberg, 1967; Lively & Sanford, 1972). In this manner it would be expected that repetition or any other experimental variable would have a better opportunity to be effective since the processing of the stimulus set would occur after the presentation of the command, and therefore can be more sensitively measured. 2) The memory set may be kept intact (i.e., equivalent in information to the physical set) however, irrelevant or redundant information may be edited from the set. The processes and predictions involved with editing were previously introduced under the information reduction model. The process of editing is identical to set size reduction, however, the time in which it occurs is the critical distinction, i.e., prior the presentation of the command or after the presentation of the command. 3) Preprocessing of the memory set may occur according to an anticipated experimental task based upon the statistical properties of the task such as the perceived number of occurences of a particular command (e.g. Poulton, 1957) or a 4) self generated task(s) that could more easily satisfy a majority of the experimental tasks. For example, if a subject during coding, alphabetically ordered the letters of the stimulus set, then completion of a task involving the search for the first or second alphabetic letter would greatly be facilitated. Since two thirds of the trials involve these commands, a subject may take this route. Another possibility is that more salient items (in this case the repeated items irrespective of physical contiguity) may be tested first according to anticipated or self generated rules. If this type of coding were to occur, the effects of the experimental variables may be negligible, since processing would occur prior to the presentation of the command. This is particularly true under the information reduction model.

5) Random or other dimensional ordering of the material may occur. The subject may change the position (or even add or delete letters) into positions that are more easily remembered, i.e., AOGD becomes ADOG. This type of subjective organization (Tulving, 1962) would facilitate retention of a set and thereby increase the probability of retrieving the target letter.

Three experiments are described in this report. The first experiment investigated the effect of repetition within a rather global context of related variables. The following two experiments attempted to focus upon specific repetition effects that test the viability of the contrasting previously developed theoretical models.

Experiment I

The purpose of this experiment was to test the effects of set size, repetition, and alphabetical location (location within the alphabet of the repeated item in the set) upon the performance in a probeless memory search task. This experiment also tested the trace strength and information reduction models in accounting for the results. Three tasks were used; Initialization-1 (IN-1) recite the first letter in the stimulus set, Identification-1 (ID-1) locate the first letter alphabetically in the set, and Identification-2 (ID-2) locate the second letter alphabetically that was in the stimulus set. These particular commands were chosen in order to have the target response be a single letter rather than a mix of single letters or entire sets. In this manner variations in the size of the response set was eliminated. When the first alphabetical letter is repeated, the ID-2 command permits a test of the effects of a repeated target (actually an intermediate target) that is independent of output processes.

It was expected that RT would increase as the difficulty of the task and set size increased (Perlmuter & Lively, 1975). According to either the trace strength or information reduction model, stimulus sets that contain a repeated item were expected to be reacted to faster than control sets that contain no repetition. Different alphabetical locations were expected to have no effect, according to the information reduction model since reduction should occur regardless of which letter was repeated. According to the trace strength model, repeated target letters should produce significantly faster RTs than nonrepeated target letters since repeated target letters possess more trace strength.

Within the information reduction model, faster RTs for stimulus sets containing repetition as compared to the control should occur for ID-1 and ID-2 due to a saving in processing time. Presumably, a subject has to search or process the entire set (exhaustive search) since any letter is a possible target candidate. However, if one of the letters if repeated fewer letters need to be processed producing a saving in RT. Since little or no processing is involved with the IN-1 task, it is expected that set size would have no effect. The information reduction model would predict repetition to have little effect for the IN-1 command, since set size reduction affects RT only if an exhaustive search is performed. According to the trace strength model, set size should have an effect upon performance for the IN-1 task. Assuming trace strength to be finite and distributed proportionately among each item (Baddeley & Ecob, 1973), the first item in the smaller set should have more trace strength than the first item in the larger set. This would result in faster RT for the smaller set. The trace strength model predicts that repetition involving the IN-1 command should facilitate performance when the first item is repeated since the first item possesses more trace strength.

Method

Subjects. There were 34 volunteer students, 10 males and 24 females, from an introductory psychology course at Virginia Polytechnic Institute and State University. These students received class credit for their participation in the experiment.

Apparatus. Typed upper case letters (pica) were simultaneously presented with a Kodak Slide Projector (Model 760H). A Gerbrand Electronic Voice Key (Model 800) stopped a Hunter Klock Counter (Model 120C) which measured subjects' vocal RT. All slide presentations were controlled electronically using solid state logic circuits with a time base error less than .03%.

Procedure and design. Subjects participated in two 45-minute sessions, separated by approximately 24 hours. Each session contained 162 trials which were unique to each session. The subject was presented with a stimulus slide for a duration of 2 seconds and this was followed by a 2-second command slide. A 9-second blank slide separated each trial. The commands were presented after the stimulus set in order to prevent the subjects from processing the set during its visual presentation. The physical presentation of the slides was actually shorter due to an approximate .7 second lag in the slide projector. The RT was measured from the instant the command slide appeared on the screen in order to control for any variance in the slide mechanism.

The stimulus sets, employing set sizes of 4 and 5 letters were randomly determined using consecutive letters (randomly ordered) from the range H - T, (e.g. JIKL).

There were three repetition conditions. One letter was repeated with the physical occurrence of the letter and its repeat either at the beginning Radj or at both ends Rsep (e.g. JJIK and JIKLJ), while the third condition contained no repeat items, Rcon (e.g. HLJKI).

For the alphabetical commands (ID-1 and ID-2), trials that contained repetition (Radj and Rsep) were further subdivided into three alphabetical locations. The alphabetical locations were; TR the target letter was repeated, TNR1 (target not repeated) for ID-1 the second letter in the alphabet was repeated and for ID-2 the first letter in the alphabet was repeated, and TNR2 the third or fourth (depending upon set size) letter in the alphabet was repeated, for example, using the ID-1; command, JJLK, KKLJ, and LLJK respectively.

To avoid guessing or probability biases each level of alphabetical location had an equal probable chance of occurrence. Also interspersed randomly among the 162 trials were 3 extraneous trials which violated the range and consecutiveness of the stimulus sets. The extraneous trials (unscored) were included to make it more difficult for the subject to comprehend the rules used in the construction of the letter sets. Only those subjects having at least two data points per condition were used in order to insure adequate data for the analysis. This eliminated two subjects from the sample. Two more subjects were unable to participate in the second session and were also eliminated.

The composition of the trials were as follows. Using Set Size 5 as an example, the alphabetical locations TR and TNR1 each had 3 replications. Also both the fourth and fifth alphabetical target locations were equally represented with TNR2 having 6 replications. For the control, no repetition condition, 3 replications were used. There were 12 presentations or data points for each of Radj and Rsep. Thus, there were 12 (Radj), 12 (Rsep), and 3 (Rcon) multiplied by 3 (the three commands) which results in half the number of data points, i.e., 81. The other half of the data points using Set Size of 4 can be accounted for similarity.

The subject was instructed to respond as quickly and as accurately as possible following the presentation of the slide command. The RT was measured from the presentation of the common slide until the subject recited a single letter.

Results and Discussion

In order to obtain more stable data and to minimize errors, only the results of the second session were analyzed, thereby treating the first session as practice. The mean of the median values of the three commands and the percentage of errors for each set size are shown in Table 1. As would be expected, the more difficult the task (in terms of processing requirements), the longer the RT and higher the errors. An ANOVA was performed on the medians for each command separately.

Initialization-1. For the command IN-1, set size of 4 produced significantly faster RTs than set size of 5. The three levels of repetition also produced significant differences. These results are summarized in Table 2. Further analysis using Scheffé's test revealed that the two conditions containing repetition, Radj and Rsep, were significantly faster ($p<.01$) than the no repetition control, Rcon, (1051, 1066, and 1362 msec respectively). No interaction was obtained between set size and repetition nor did Radj and Rsep differ significantly from each other, $p>.05$.

According to the limited-capacity trace strength model (Baddeley & Ecob, 1973) the more items there are in a set the less amount of trace strength is available for each item. Thus, the target letter for the set size of 5 (SS-5) would have less trace strength than the target

TABLE 1

Mean RT and Percentage of Errors for each Command and Set Size for Experiment I

	Set Size 4		Set Size 5	
Task	Mean RT	% Errors	Mean RT	% Errors
IN-1	1106.26	.35	1213.47	.93
ID-1	1425.21	1.09	1520.21	1.06
ID-2	1443.18	1.09	1711.47	1.93

TABLE 2

Summary ANOVA Table for the IN-1 Command in Experiment I

Source	df	SS	MS	F
SS (Set Size)	1/29	517240	517240	6.774*
REP (Repetition)	2/58	3696370	1848180	32.798**
SS x REP	2/58	12392	6196	.117

* = $p < .025$
** = $p < .005$

letter for the set size of 4 (SS-4). In this manner the set size effect could be explained. The information reduction model could also account for the set size effects if it is assumed that an exhaustive scan is performed of the entire set even if it is not required by the command.

The target letter for IN-1, if repeated would have more of the available trace strength than a nonrepeated target letter. Faster RTs to the repeated target letters were expected according to the trace strength model (Norman & Wickelgren, 1969). Retrieval time is related to the amount of trace strength an item possesses and repeated items are assumed to have more trace strength. The information reduction model also predicts with these results since repetition is expected to reduce the set size and therefore facilitate RT (Morin, Konick, and Hoving, 1973). The crucial distinction between the two models, i.e., examination of trials involving nonrepeated target letters, cannot be performed. The reason being that for the IN-1 command, a repeated item was <u>always</u> the target letter. Besides this limitation there is the possibility that the equivalence of repeated and target items may have induced search or response strategies.

<u>Identification-1</u>. For the ID-1 task, SS-4 was significantly faster than SS-5, see Table 3 for the ANOVA source table. The interaction between set size, repetition, and alphabetical location was also significant. Since the interaction was significant all pairwise comparisons of each level for each variable was performed. Scheffe's test revealed that SS-4 was significantly faster ($p<.05$) than SS-5 for both TNR1 (1275 and 1553 msec) and TNR2 (1324 and 1588 msec) under the Rsep conditions. Thus, set size effects would appear to be more pronounced

TABLE 3

Summary ANOVA Table for the ID-1 Command in Experiment I

Source	df	SS	MS	F
SS (Set Size)	1/29	812345.0	812345.0	8.534**
REP (Repetition)	1/29	2722.5	2722.5	.015
SS x REP	1/29	333428.0	333428.0	1.325
AL (Alphabetical Location	2/58	134545.0	67272.4	.706
SS x AL	2/58	342008.0	171004.0	.813
REP x AL	2/58	444160.0	222080.0	1.442
SS x REP x AL	2/58	1458800.0	729401.0	4.433*

* = $p<.05$
** = $p<.01$

if the item and repeat were separated and that a letter other than the target wes repeated. Set size differences would effectively be eliminated for the Radj condition if the subject consistently responded with the adjacent repeated letter. If this were the case then in sets containing repetition, lower errors would be expected for the adjacent repeated target letters than for target letters that were not repeated. The average percent error rate across set size for the three alphabetical locations were TR = 6.7, TNR1 = 9.4 and TNR2 = 4.4. As can be seen, error differences do not appear to lend support to this type of "emphasizing" response strategy. The only remaining significant comparison revealed that within SS-4 the TR condition was slower ($p<.05$) than the TNR1 condition when the item and repeat were separated, (1577 and 1275 msec respectively). Within the trace strength framework, having the target letter repeated should have provided the repeated item with more trace strength than a nonrepeated target condition. Since the amount of trace strength is related to how fast an item is retrieved, it was predicted that having the target letter repeated would facilitate rather than inhibit RT.

The information reduction model predicts no differences between the two alphabetical locations. If a subject always processed nonrepeated letters first when repetition formed a "bracket" around the items then due to lack of rehearsal (maintenance of an items trace due to repeated comparisons) one would expect to find repeated target letters reacted to slower than nonrepeated target letters. However, this explanation cannot account for the obtained differences occurring only for

SS-4, including the no significant difference between the TR and TNR2 conditions.

The control no repetition condition (Rcon) was compared with each alphabetical location. It was found that the TNR1 condition for SS-4 was significantly ($\underline{t}(29)=2.70$, $\underline{p}<.005$) slower than the control (1275 and 1515 msec respectively) when an item and its repeat were separated (Rsep condition). It was also found for SS-5 that the TNR2 condition was significantly slower ($\underline{t}(29)=2.26$, $\underline{p}<.02$) than the control (1397 and 1579 msec respectively) when an item and its repeat were adjacent (Radj condition). Neither of these differences were expected according to the trace strength model. This model would not have predicted any condition in which repetition occurred would be slower than the control, (Rcon condition). The information reduction model also would not predict these differences, since repetition should have reduced the memory set, thus facilitating the search for the target letter.

Identification-2. For the ID-2 command, set size, repetition, and alphabetical location all had significant main effects. Set size also significantly interacted with repetition. These results are summarized in Table 4. Breakdown of the interaction revealed that in the Rsep condition SS-4 was significantly faster than SS-5, (1416 and 1798 msec respectively). The lack of a set size effect for the adjacent repetition condition was not expected within the trace strength or information reduction models. It is hard to arrive at an explanation of how adjacent repetition nullifies the set size effect without looking at response strategies. A subject may consistently respond with the repeated letter, since it stands out and is "emphasized" in the set. In this manner,

TABLE 4

Summary ANOVA Table for the ID-2 Command in Experiment I

Source	df	SS	MS	F
SS (Set Size)	1/29	6478370	6478370.0	11.991**
REP (Repetition)	1/29	318741	318741.0	5.750*
SS x REP	1/29	1154750	1154750.0	8.593**
AL (Alphabetical Location)	2/58	1484140	742070.0	4.171*
SS x AL	2/58	571546	285773.0	2.196
REP x AL	2/58	137939	68969.4	.311
SS x REP x AL	2/58	579874	289937.0	1.793

* = $p<.05$
** = $p<.01$

lower error rates would be expected for conditions when the target letter is repeated. Analysis of error rates revealed that the mean percent error across set size for each alphabetical location were TR=7.2, TNR1=7.7 and TNR2=6.7. It does not appear that this particular response strategy is strongly supported.

Analysis of the alphabetical location main effect using Scheffé's test revealed that TNR1 was significantly faster ($p<.05$) than TNR2, (1505 and 1661 msec respectively). Having the first alphabetical letter in the set repeated results in faster RT than having other nontarget letters repeated. On the ID-2 task it is necessary to locate the first letter alphabetically in order to find the second. According to the trace strength model having the first item repeated presumably increases its trace strength. This would facilitate the retrieval of the first alphabetical letter. No significant difference was found between the TR and TNR2 conditions. Having the target letter repeated should increase its trace strength and therefore effectively facilitate RT. The information reduction model would have predicted no differences between the TNR1 and TNR2 conditions.

The use of t-tests revealed that for SS-4 in Radj the TR and TNR1 conditions (1404 and 1396 msec) were significantly faster ($t(29)=2.31$, $p<.01$ and $t(29)=2.59$, $p<.007$) than the control no repetition condition (1818 msec). For SS-4 in the Rsep condition TR and TNR1 (1347 and 1401 msec) were significantly faster ($t(29)=2.95$, $p<.003$ and $t(29)=2.88$, $p<.003$) than the control condition. Comparisons involving Rcon for SS-5 revealed no significant differences. Thus it appears with SS-4, regardless of the alphabetical location of an item and its repetition, having the target or intermediate target (first letter alphabetically in the set) repeated facilitates the ID-2 task. These results are supportive of the trace strength model. Repeated target or intermediate target letters presumably possess more trace strength then nonrepeated letters and therefore should be retrieved faster. The information reduction model predicts all sets containing repetition to be significantly faster than the control no repetition condition. Since TNR2 was not significantly faster than the control, the information reduction model is questionable as a possible explanatory model.

Additional Analysis. An examination of the error data revealed that the average number of errors per subject for the second session was 10.13 accounting for about 6% of the data. The error rate in comparison to those obtained by Perlmuter & Lively (1976) was quite low. In their experiment the task of identification contributed an error rate of 17%. The error rate was more comparable to that obtained by Baddeley & Ecob (1973) of 6.3%. The correlation between RT and the proportion of errors in each condition was highly significant ($r=.587$, $p<.005$) indicating that more difficult items (items that have longer RTs) are associated with higher error rates. This makes the results more difficult to interpret, since the more difficult items would contribute less data points. This would make the median value for the more difficult items less stable.

According to the same-different model (Parkman, 1973) a subject increments an alphabetic register until a match is found. If a subject misses the match for the target letter, then the next alphabetic letter in the set may be matched. Thus, with each error made one more increment is necessary to make a match. In this manner RT for errors should be a function of the difference between the target letters alphabetical position and alphabetical position of the erroneous letters. This assumes that errors are predominantly due to missing a match rather than matching a wrong (not identical) letter. However, it was found that the RT of errors was not significantly related to differences in the number of letters between the target and incorrect response, (r=-.038, p<.53). Thus the result is not supportive of the same-different model.

Lovelace & Spence (1972) reported longer latencies in naming letters in the latter portion of the alphabet as compared to letters earlier in the alphabetic sequence. In the present study no relationship was found between RT and the target letter's location in the alphabet, (r=.024, p<.68). This would indicate that there was no systematic effect due to the range of letters used in the experiment.

Stage Analysis. Set size interacted significantly with repetition and alphabetical location for the ID-1 command. Also, set size interacted significantly with repetition for the ID-2 command. According to Sternberg (1969), an interaction implies that the factors are affecting the same processing stage. The initial assignment of processes to stages is a very important basic assumption (Taylor, 1976) which must be considered. It has been shown that set size does effect the duration of the task (Perlmuter & Lively, 1976). Theoretically, since the probeless memory search is exhaustive for the alphabetical tasks (each item must be considered), changes in set size should affect the duration of the comparison process. Having more items to consider directly implies that more items must be compared, thus increasing the duration of this stage. In this manner one could surmise (as Sternberg did) that the effects of set size are solely on the comparison stage. Variables that effect encoding are not measured in this experiment since RT was determined after the termination of the stimulus set. Therefore, the variance of the RT scores must be accounted for by variance in task processing (comparison stage) and/or output processes (response execution stage). Of course additional stages may exist, but at this time only the encoding, comparison, and response execution stage will be addressed, see Figure 1. The change in the number of letters between an item and its repeat appears to affect the comparison stage. However, the exact nature of the effect is elusive, due to the complexity of the interactions.

Conclusion. The overall results are rather difficult to interpret. Neither the trace strength or information reduction models were adequately supported. The inconsistent interactions of the variables and the variability of the data (scores ranged from .3 to 9.3 seconds) contributed to the difficulty. It is difficult to tell whether coding variability or altered strategies affected the results, since a consistent alternative processing scheme is not apparent.

However there is one apparent strategy which indicates that the high variability of the data may reflect reactions to individual stimulus set differences. Any stimulus set that contained the letter H for the alphabetical commands (ID-1 and ID-2) had the fastest RT within its condition. Statistical significance of the effect is difficult to assess since the stimulus sets in question are individual data points (trials) and may be missing (errors) across subjects. However, the facilitated RT was found in every stimulus set containing the letter H. This indicates that the subject may have utilized the restricted range of the

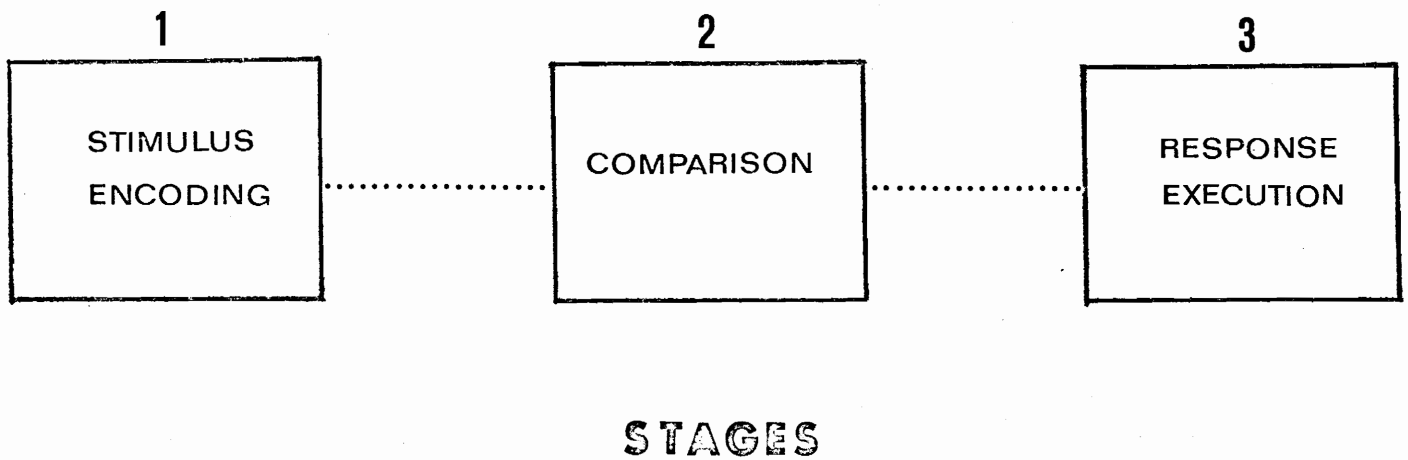

Figure 1. The three proposed stages of the probeless memory search task.

stimulus sets and learned that if *H* occurred it was automatically the first alphabetical letter in the set. This would effectively make the alphabetical task much easier. For ID-1 the strategy would be upon locating an *H*, simply respond "H". For ID-2 upon locating an *H* the subject simply had to respond with the next alphabetical letter, "I".

Another experiment was needed to determine if any of the significant differences that were found are meaningful and not due to other possible confoundings (e.g. high variability of the data). In the following experiment a simplification and redesign of Experiment I was attempted. Hopefully some of the questions unanswered in the present study will be answered.

Experiment II

Experiment II served to improve the design of Experiment I by; 1) increasing the number of extraneous trials in order to make it more difficult for the subjects to recognize stimulus construction rules, 2) using three daily sessions instead of two so that the subjects would be better practiced and less error prone, 3) using a minimum of 10 data points instead of 3 in obtaining the median performance in each condition, thus providing more stable estimates, and 4) having repeated target and nonrepeated target letters equally probable in the IN-1 condition.

This experiment used only the IN-1 and ID-2 task and singularly employed the set size of 4 in order to simplify the design. A pilot study was performed using only these two tasks and it was found that by the third session a majority of the subjects could anticipate the correct response before the presentation of the command. Whenever the first letter of the set was also the second letter alphabetically the target letter was the same for both commands, e.g., JJIK. In order for the subject to respond before the onset of the command, a considerable amount of processing had to take place while the stimulus slide was being presented. This type of preprocessing probably occurred during Experiment I, but since it was impossible for any single target letter to satisfy all three commands, anticipation, (responding before the command) never developed. Preprocessing probably affected Experiment I to a lesser extent since one more task was involved making preprocessing more difficult. With processing time as the dependent measure, the effects of preprocessing pose a serious problem. To minimize this problem, Experiment II used shorter stimulus set durations with the expectation that the shorter durations would not allow time for preprocessing.

Subjects. There were 20 volunteer students, 8 males and 12 females, from an introductory psychology course at Virginia Polytechnic Institute and State University. These students received class credit for their participation in the experiment.

Apparatus. The same apparatus was used in this experiment as was employed in Experiment I.

Procedure and Design. Subjects participated in one 25 minute session on each of three consecutive days. Each session contained 140 trials with sessions 1 and 3 containing identical stimulus sets. The subject was presented a stimulus slide with a duration of 1 second followed by a 2 second command slide. A 3 second blank slide separated each trial. Only the two commands IN-1 and ID-2 were used.

Stimulus sets employing only four consecutive letters were randomly generated by a computer program which sampled from the letters H-T. The same types of repetition were used as in Experiment I with one exception. The condition in which the item and its repeat were separated (Rsep condition) was replaced by another repetition condition, Rend which had an item and its repeat occurring at the end of the stimulus set, e.g., KLJJ. The use of Rend permitted the equalization of the probability that the target item was repeated or not repeated for the IN-1 command. For ID-2 the two types of repetition, Radj and Rsep were subdivided into three alphabetical locations TR, TNR1, and TNR2. The control no repetition condition (Rcon) was also used with both commands. Interspersed randomly among the 140 trials were 20 extraneous trials (unscored) which violated stimulus set construction rules.

Results and Discussion

The data analysis was performed only on the third session in the same manner as in Experiment I. The average RT for the IN-1 command was 950 msec and for the ID-2 command 1817 msec. The analysis of variance for the IN-1 command showed no significant difference between the repetition conditions. The analysis of variance for the ID-2 command revealed no significant effects of repetition or alphabetical location. Also, the use of t-tests between the repetition conditions and the control (Rcon) revealed no significant differences, ($p<.05$).

Clearly this was not expected. Visual inspection of individual subjects revealed that a majority of the subjects had similar curves across conditions. A Q-type factor analysis was performed resulting in 13 subjects loading high (factor loading above .50) on the first factor. The high loadings on the first factor indicate that the 13 subjects performed similarly across conditions. A possible label for the first factor may be the subjects who did not preprocess the letter sets. It would be expected that if a subject preprocessed then the mean difference between the two commands across conditions would be lower than for non-preprocessing subjects. The reason for this is that preprocessing would allow the subject to respond relatively faster to the ID-2 command than the subjects that did not preprocess, thus attenuating the difference between ID-2 and IN-1. Those subjects who showed the smallest differences between both commands were all, with a single exception, the 7 subjects who loaded low on the first factor. The exception was a subject who had a generally higher RT than the average and whose curve across conditions differed from the majority. This may indicate that the 7 low loading subjects were probably subjects who were preprocessing.

Analysis of variance was conducted for the 13 high loading subjects for both the IN-1 and ID-2 commands. The ANOVA for the IN-1 command revealed no significant differences between the repetition conditions. The trace strength model would have predicted the control (Rcon) to be significantly slower than Radj, whereas the information model does predict the obtained no difference. For ID-2, the only significant effect was for alphabetical location, $F(2,24) = 6.13$, $p<.01$. Breakdown of this effect using Scheffé's test revealed TNR2 to be significantly faster, $p<.05$, than both TR and TNR1, see Figure 2. This result was not expected by either the trace strength or the information reduction model. It appears that repetition facilitates performance, only if the repeated letter was not a target or intermediate target (first alphabetical letter for the ID-2 command). The use of t-tests revealed that the control condition (Rcon) was also significantly slower than the TNR2 condition, $t(12)=3.96$, $p<.001$. These results were not predicted by the trace strength model, nor are they supportive of the information reduction model.

The lack of a repetition effect for the IN-1 command seriously questions the viability of the trace strength model. Repeated target letters should have been retrieved faster than nonrepeated target letters. The information reduction model makes this prediction only if an exhaustive search is performed. The lack of repetition effects may indicate

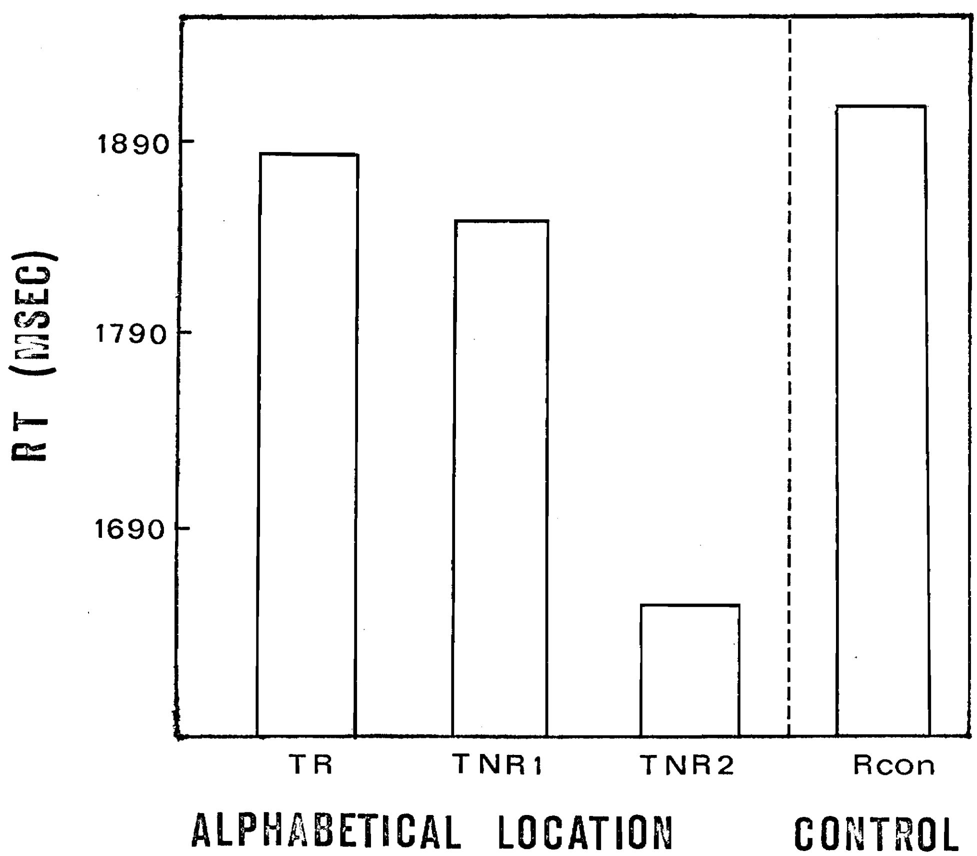

Figure 2. Mean reaction time for the three alphabetical locations and the control condition.

an exhaustive search is not performed, and that the subjects either have direct access to the first letter or perform a self-terminating search. The RT to the different alphabetical locations were in the opposite direction of that predicted by the trace strength model. The repeated nontarget letters facilitated RT rather than the repeated target letters.

An extension of the information reduction model is necessary to accommodate the repetition effects observed for the ID-2 command. It may be the case that the three alphabetical location conditions are reduced in set size according to the information reduction model. However, set size reduction involving an item may interfere with the processing of its repeat. Since the TNR2 condition does not possess a repeated target or intermediate target letter the interference would not occur. However, the exact nature of the interference is not clear. The proposal of two mechanisms i.e. facilitation and interference is highly speculative but it is difficult to arrive at a model explaining repetition effects only occuring when the target or intermediate target letter is repeated. In the TNR2 condition the repeated letter is not involved as a response, yet facilitation occurred. This lends support to the results of Experiment I that repetition influences the comparison stage rather than output processes.

On the average, there were 11.7 errors per subject accounting for approximately 8% of the subjects responses. Higher errors were again associated with the items that had the longest RTs, (r=.88, p<.01).

In this experiment, 35% of the subjects performed differently from the majority which represents 7 subjects. The belief that these 7 subjects were preprocessing is only speculative. An alternative hypothesis may also be just as correct. It is clear that another experiment is needed in order to test the reliability of these findings without any partitioning of the subjects. It is the purpose of Experiment III to replicate Experiment II for the ID-2 command in order to determine if repetition and alphabetical location are effective variables.

Experiment III

When an item and its repeat were separated (in Experiment I) the use of repetition appeared to produce different results than when the letters were adjacent (i.e. inhibition of RT). The Rsep condition was added to the design of Experiment III in order to test the reliability of this difference. Experiments II and III in all other aspects were identical except for the meaning of the IN-1 command. In this experiment the subject was to respond to the IN-1 command with the last letter in the stimulus set instead of the first. It was suggested in Experiment I that a serial exhaustive scan of the letter set may occur before the response of the first letter. This type of search would be more likely if the subject had to respond with the last letter since the last letter may only be accessible by scanning serially through the preceding letters. If this is true then according to the information reduction model, repetition should facilitate the search due to the reduction of the number of items to search. To avoid confusion the label IN-1 will be changed to IN-4.

Subjects. There were 11 volunteer students, 8 males and 3 females, from an introductory psychology course at Virginia polytechnic Institute and State University. These students received class credit for their participation in the experiment.

Apparatus. The same apparatus was used that was employed in Experiments I and II.

Procedure and Design. Subjects participated in a 30 minute session on each of 3 consecutive days. Each session contained 160 trials. The sessions used the same stimulus sets as the second session of Experiment

II with the minimum number of data points per condition of 8 instead of 10. Also there were 20 additional Rsep trials. The reduction in the number of data points was necessary in order to add the Rsep condition and still maintain a 30 minute session. Because of an oversight in the design of the experiment, some of the conditions within a command had an unequal number of replications. This difference was at the most one or two trials across the conditions and therefore it is not anticipated that this slight imbalance would affect a subject's performance. The subject was instructed to respond with the last letter in the stimulus set for the IN-4 command. Other than the above changes, Experiment II and III were identical.

Results and Discussion

Initialization-4. The IN-4 command was reacted to on the average 913 msec faster than the ID-2 command. The analysis of variance for the IN-4 command revealed no significant differences between the repetition conditions. The mean RT for this command was 1146 msec which is 196 msec slower than IN-1 in Experiment II. This translated to about a 65 msec search rate per item which is about 27 msec slower than the results obtained in the probe recognition task, Sternberg (1966, 1969). RT for the ID-2 command indicated that the subjects in this experiment were also slower on this command by 243 msec. This result seriously questions the accuracy of the 65 msec search rate. It appears that the search for the final letter in the set is not influenced by repetition, irrespective of whether the target letter is repeated or nonrepeated. This lends little support to either the trace strength or information reduction models. The trace strength model would have predicted repeated target letters to have faster RTs than nonrepeated target letters. According to the information reduction model, if a search is conducted then any condition containing repetition should be facilitated. The results suggest that set size reduction due to repetition does not occur. It may be the case, however, that scanning of the set does not take place. If this is true then little can be gained by reducing the set since changes in set size would not influence RT unless an exhaustive scan occurs. It thus appears that the subject has direct access to the last letter without scanning through the entire set. This result is at variance with the scanning model suggested by the set size effects for IN-1 in Experiment I. However there were problems in interpreting the IN-1 results in Experiment I (e.g. in sets containing repetition there were no nonrepeated targets) and the IN-1 and IN-4 commands may not be comparable tasks.

Within the traditional trace strength framework, repeated targets should have had significantly faster RTs than nonrepeated targets. This indicates that the trace strength model as it stands is not viable since repetition does not affect the latency of retrieval. According to Experiment I, for the alphabetical commands, repetition appears to influence the comparison processes. Comparisons among letters are not required for successful execution of the IN-4 command and repetition effects were not found. This lends support to the contention that repetition primarily affects the comaprison stage.

Identification-2. An analysis of variance performed for the ID-2 comman revealed repetition was the only significant effect, $F(2,20)=6.62$,

$p<.01$. Breakdown of this effect using Scheffé's test revealed that having an item and its repeat separated produced significantly slower RTs ($p<.05$) than when repetition was adjacent, either at the beginning or end of the stimulus set, see Figure 3. Without additional assumptions, neither the trace strength or information reduction model would have predicted this difference.

The use of t-tests revealed that the two adjacent repetition conditions Radj and Rend were significantly faster than the control Rcon, $t(10)=2.14$, $p<.03$ and $t(10)=3.43$, $p<.03$, respectively. Thus, when an item and its repeat are physically separated by nonrepeated intervening letters, the facilitating effects of repetition disappears.

Although adjacent repetition facilitated RT as was predicted by the trace strength model, the expected difference between repeated and nonrepeated target letters was not found. This lack of difference seriously questions the viability of the trace strength model. Since the facilitating effects of repetition do not appear to occur during retrieval (e.g. no repetition effects were found for the IN-4 command) it may be the case that stronger trace strength is only facilitated during the comparison process. In this manner the type of letter repeated (target vs. nontarget) would not matter. Thus, one could say that in the process of comparing two items, having one item possessing more strength increases the speed of the comparison process. However, the exact mechanism of such a process is unclear and the effect can be more parsimoniously explained within the information reduction framework. It may be the case that when a portion of the limited amount of trace strength (Baddeley & Ecob, 1973) is deposited for each item, a repeat

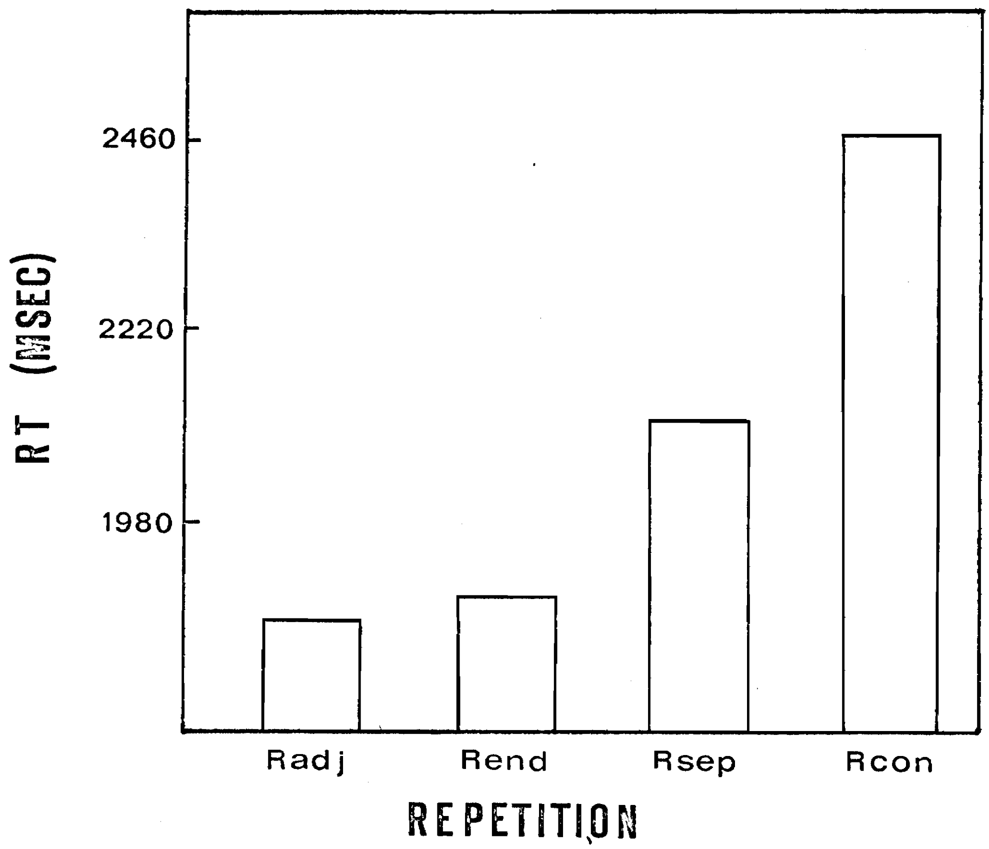

Figure 3. Mean reaction time for the three repetition and control conditions.

of an item would receive 0% of the available trace strength. If it is also assumed that this process is a function of the physical proximity of the item and its repeat then the repetition effects obtained for the ID-2 command can be explained. For example, the unique letters in the set RRTS would receive more trace strength then the set RQTS (one third of the available trace strength vs. one quarter). In this manner the lack of difference between repeated and non-repeated target letters would be predicted since repetition would enhance the retrievability of each unique item. When the item and its repeat are separated (e.g. RTSR) each item would receive one quarter of the available trace strength and thus incur no savings in processing time during the comparison stage. However this model would predict that sets containing repetition for the IN-4 command should be faster than the control condition. Since this result was not obtained its appropriateness may be questioned.

The results (except for the Rsep condition) fit well with the predictions made by the information reduction model. Repetition facilitated RT regardless of which item was repeated. Thus it appears that set size reduction occurs due to the redundant material. However, the information reduction model as it stands, predicts facilitation regardless of where the item and its repeat are located in the set. Since repetition effects were not found for the Rsep condition, additional assumptions must be made to incorporate this result.

Items which are perceptually distinct tend to be recalled better than control nonisolated items (Von Restorff effect). The adjacent repetition in a set may perceptually "stand out" emphasizing the fact that there are two letters alike. This, coupled by the fact that the adjacent repetition always occupied more noticeable serial positions (first two or last two) probably enabled the subjects to perceive the two letters as one more so if the letters were not so perceptually isolated. The reduction may take place as early as the encoding stage, just as other changes in the perceptual properties of items affect this stage, (Sternberg, 1967). When an item and its repeat are separated set reduction would most likely not occur until a redundant match is performed, thus incurring more processing time than with adjacent repetition.

Melton (1963) found that recall errors increased as the number of intervening items increased between repeats. An inhibitory effect has also been found for this type of repetition (e.g., Wolf & Jahnke, 1968). Wolfe and Jahnke measured errors of retention of 7-digit strings in which a number was repeated. They found that performance was inhibited (more errors) in all proximal locations of an item and its repeat except when the items were more closely adjacent. Explanations of this phenomena, called the Ranchburg effect (see Jahnke, 1969 for a review), rely on the process of output interference associated with the active retrieval of the redundant element (e.g. Crowder, 1968a, 1968b, and Jahnke & Nowaezyk, 1975). However, this type of explanation is not viable in the present experiment, since the output consists of only one letter, making response interference between an item and its repeat unlikely.

Reasons for the discrepancy in results between Experiment II and III are not clear. The results of Experiment II may be due to a capitalization of the effects of partitioning the subjects. However, the robustness of the effects warrant against this type of explanation. The only procedural change between Experiment II and III was the requirement for the IN-1 command. This would suggest that alternate strategies influenced by this command are responsible for the discrepancies. Strategies that would explain the discrepant results are difficult to develop and should be based on further experimentation.

Errors. There were 14.5 errors per subject accounting for approximately 9% of the total responses. Again high error rates were associated with the slower conditions, ($r = .80$, $p<.01$).

Summary

In all three experiments, the Initialization command produced the shortest average latencies, with the ID-2 command possessing the longest average RT. Also, in Experiment I the set size of 4 generally produced shorter RTs than a set size of 5. These results support those obtained by Perlmuter and Lively (1976) that RT becomes longer as the difficulty of the task or size of the set increases.

Both Experiments II and III found repetition to be facilitative only under certain conditions. In Experiment I there were interactive effects between repetition and set size for the alphabetical commands suggesting that they influence a common stage - the comparison stage, (Sternberg, 1966, 1969). Experiment II and III support this contention since repetition effects were only found when alphabetic comparisons were required, i.e. for the ID-2 command.

In Experiment II, repetition effects were not found for the IN-1 command. According to the trace strength model repeated target letters should possess more trace strength and therefore facilitate retrieval. Thus this result seriously questions the appropriateness of the trace strength model. Alternatively the information reduction model predicted facilitation for any condition containing repetition, if an exhaustive scan or comparison is performed. The lack of repetition effects for the IN-1 command could be explained if it is assumed that an exhaustive scan was not performed. It may not be necessary to consider all the letters of the set when only the first letter needs to be retrieved. Thus, a self terminating search may be suggested. To test this assumption the meaning of the IN-1 command was changed in Experiment III. Under this modified condition the subject was required to retrieve the last letter in the set. In this manner if a self terminating search is performed, set size reduction should be observed. However, the lack of repetition effects suggest that either information reduction does not occur or that access to the last letter is readily available without having to scan or proceed through prior items. Since repetition effects were found for the ID-2 command which supported an information reduction model the latter view is a more tenable possibility.

In Experiment II repetition was facilitative only if a letter other than the target or intermediate target was repeated. By contrast the trace strength model would have predicted facilitation only for repeated target letters, (Baddeley & Ecob, 1973). The results can be accommodated by the information reduction model if it is assumed that interference occurs between set reduction and the processing of the repeated target or intermediate target letter. However the results of Experiment II were only obtained by eliminating a number of nonconforming subjects from the analysis. One of the purposes of Experiment III was to test further the results of Experiment II in order to provide a more sound empirical base for theoretical development.

The effects of repetition in Experiment III were rather unambiguous. Repetition facilitated RT in all conditions except when the item and its repeat were separated by nonrepeated intervening letters. Having the target repeated did not produce faster RT than the no repetition control. This result is contrary to the predictions of the trace strength model that having the target letter repeated should facilitate retrieval.

Except for the lack of repetition effects for the nonadjacent repetition condition the results are more supportive of the information reduction model. Several explanations were developed to account for the lack of repetition effects for this condition. A phenomenon similar to the Von Restorff effect may influence the processing of the set. Subjects may reduce sets containing adjacent repetition early in the trial due to the "emphasizing" effects of the perceptually distinct repetition. In contrast, when repetition is separated and not distinct, set reduction would not occur.

In conclusion, the effects of repetition appear to facilitate RT under certain conditions. Repetition effects in Experiments II and III were only found for the alphabetical command. This supports evidence found in Experiment I that savings in RT occur during the comparison stage. It also appears that the intraserial location of an item and its repeat has a major role in determining the repetition effect. When an item and its repeat are adjacent, latency is significantly shorter than for the no repetition control. However, having an item and its repeat physically separated in the set eliminates the repetition effect. These results were supportive of an information reduction model which reduced distinct identical elements. In general all three experiments found that intraserial repetition influences RT in the probeless memory search task and that the influence occurs during the comparison stage.

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APPENDIX

EXP 1 BREAKDOWN OF CONDITIONS (C1-C34).

CND	COM	SS	REP	AL
1	ID-1	SS-4	RADJ	IR
2	ID-1	SS-4	RADJ	INR1
3	ID-1	SS-4	RADJ	INR2
4	ID-1	SS-4	RSEP	IR
5	ID-1	SS-4	RSEP	INR1
6	ID-1	SS-4	RSEP	INR2
7	ID-1	SS-4	RCON	====
8	ID-1	SS-5	RADJ	IR
9	ID-1	SS-5	RADJ	INR1
10	ID-1	SS-5	RADJ	INR2
11	ID-1	SS-5	RSEP	IR
12	ID-1	SS-5	RSEP	INR1
13	ID-1	SS-5	RSEP	INR2
14	ID-1	SS-5	RCON	====
15	ID-2	SS-4	RADJ	IR
16	ID-2	SS-4	RADJ	INR1
17	ID-2	SS-4	RADJ	INR2
18	ID-2	SS-4	RSEP	IR
19	ID-2	SS-4	RSEP	INR1
20	ID-2	SS-4	RSEP	INR2
21	ID-2	SS-4	RCON	====
22	ID-2	SS-5	RADJ	IR
23	ID-2	SS-5	RADJ	INR1
24	ID-2	SS-5	RADJ	INR2
25	ID-2	SS-5	RSEP	IR
26	ID-2	SS-5	RSEP	INR1
27	ID-2	SS-5	RSEP	INR2
28	ID-2	SS-5	RCON	====
29	IN-1	SS-4	RADJ	====
30	IN-1	SS-4	RSEP	====
31	IN-1	SS-4	RCON	====
32	IN-1	SS-5	RADJ	====
33	IN-1	SS-5	RSEP	====
34	IN-1	SS-5	RCON	====

SUBJECT	C1	C2	C3	C4	C5	C6	C7
1	2967.0	2915.0	3440.5	2782.0	2636.0	2656.0	2906.0
2	1274.5	1018.5	1245.0	1096.0	952.5	869.0	2404.5
3	1399.5	2552.5	3614.0	3098.0	1581.0	1562.0	1653.0
4	1426.0	2335.0	1565.0	2188.0	1446.5	1417.0	2291.0
5	1158.0	1984.0	1126.0	2192.5	1333.5	2052.0	1947.0
6	1260.0	1659.0	1530.0	2155.5	1041.5	1568.0	863.5
7	2387.0	1299.5	1515.0	1625.0	1170.0	1054.0	2094.5
8	2091.0	1968.0	2500.0	2231.0	1695.0	2021.0	2211.0
9	3668.0	2593.0	4023.0	4530.5	2878.0	4576.0	4255.0
10	1275.0	1918.0	1663.5	1922.0	2297.5	2113.0	2011.0
11	1181.5	898.0	1037.0	1477.0	1488.0	1013.0	1418.0
12	2587.0	1882.5	2588.0	2052.0	2108.5	1673.0	2961.0
13	1172.0	1214.5	1160.5	1250.5	1106.0	1395.0	1049.5
14	1046.0	1195.5	985.0	1102.0	1549.0	1010.0	1974.0
15	1135.5	1185.0	1452.0	1129.0	1059.0	1025.0	1177.0
16	1304.0	1393.0	1469.0	1201.0	934.0	921.0	1462.5
17	758.0	1035.0	852.0	819.0	739.0	887.0	851.0
18	1069.0	1312.0	1212.0	1114.0	1101.0	1376.0	749.5
19	1028.0	1734.5	1121.0	1721.0	928.0	922.5	806.5
20	1046.0	1045.0	1319.0	1126.0	920.0	1173.0	896.0
21	893.0	1368.0	2006.0	1260.0	1167.5	652.0	1655.0
22	1211.0	1319.5	1012.0	1064.0	1279.5	971.0	1347.0
23	939.0	1172.0	883.0	1263.0	890.0	900.0	1179.0
24	789.0	1016.0	746.0	729.0	644.0	686.0	770.0
25	736.5	820.0	777.0	771.0	711.0	1017.0	654.0
26	924.0	962.0	917.0	1040.0	790.0	919.0	914.0
27	779.0	647.0	698.0	740.0	719.0	602.0	780.0
28	655.0	745.0	752.0	815.0	830.0	492.0	690.0
29	2636.0	2040.0	1710.5	1912.0	1306.5	1216.0	631.0
30	813.0	717.5	783.0	904.5	957.5	974.0	841.0

SUBJECT	C8	C9	C10	C11	C12	C13	C14
1	2637.0	2693.0	2562.0	2527.0	3490.0	2625.5	3131.0
2	918.0	797.0	1005.0	1139.0	1070.5	1305.0	1322.5
3	2385.0	1837.0	1586.5	2278.0	1995.0	2334.0	2121.0
4	1802.0	1797.0	2274.5	1740.0	3314.0	2126.0	1741.0
5	2029.0	2436.0	2206.0	2464.0	2004.0	2682.0	2191.0
6	1099.0	861.0	1582.0	2329.5	1971.0	2194.5	955.5
7	2015.0	1250.0	1533.0	1669.0	2481.0	1808.0	1929.0
8	2590.0	712.0	2216.0	2675.5	2304.0	2811.0	1330.0
9	3823.0	7223.5	2743.5	2846.0	3424.0	2968.0	3615.5
10	1725.0	1686.5	1653.5	1769.0	2336.0	1902.0	1829.0
11	1190.0	1615.0	1360.5	1208.0	1362.0	1242.5	1692.0
12	2391.0	2821.0	1737.5	1955.0	1588.0	2510.0	2161.0
13	1624.0	1226.0	1145.0	1299.5	1313.0	1460.0	1120.0
14	1466.0	1377.0	1124.0	820.0	1051.0	1286.5	2149.0
15	1422.0	1456.0	1275.5	1458.0	1500.0	2142.0	2246.0
16	904.0	2054.0	1457.0	885.0	711.0	1057.0	1199.0
17	889.0	807.0	899.0	722.0	922.0	999.0	851.0
18	1170.0	822.0	1002.0	1538.0	1145.0	984.5	1028.0
19	846.0	798.5	1073.0	2231.0	1676.0	1015.0	1546.0
20	1513.0	1238.0	1280.5	1162.0	1720.0	1102.0	1648.5
21	1687.0	980.0	1347.0	1347.0	1527.0	1508.0	1419.0
22	1139.0	1228.0	1151.0	1731.0	1082.0	1286.0	1150.0
23	1000.0	1206.0	966.5	944.5	944.0	1097.0	1547.0
24	807.0	719.0	692.0	661.0	610.0	710.5	764.0
25	725.0	865.0	741.0	711.0	666.0	845.5	755.0
26	1508.5	818.0	975.0	1087.0	1017.0	1124.5	1300.0
27	662.0	738.0	933.0	681.0	812.0	830.5	617.0
28	910.0	914.0	736.0	548.0	579.0	715.0	1026.0
29	2238.0	2761.0	1460.0	1894.0	1081.5	1878.0	1882.0
30	879.0	688.5	1191.5	770.0	889.0	1086.0	1103.0

SUBJECT	C15	C16	C17	C18	C19	C20	C21
1	2852.5	2463.0	2265.0	2647.5	2877.0	2710.0	2635.0
2	1045.0	829.0	974.5	765.5	867.0	853.0	918.0
3	1552.0	2272.0	2439.0	1575.0	2478.0	1756.0	3573.0
4	1673.0	1293.0	1060.0	1704.0	1033.0	1191.0	2245.5
5	1948.0	1853.0	2026.0	2165.5	1163.5	1932.0	2826.0
6	1352.5	1750.0	1389.0	1301.0	1488.5	1208.0	1255.0
7	1267.0	1765.0	1905.0	1452.5	1557.0	1334.0	1984.0
8	1768.5	1760.0	3916.0	1076.0	2551.0	2254.0	2408.0
9	3365.0	3646.5	4458.5	2957.0	2795.5	5256.5	3448.0
10	1513.0	1254.5	1359.0	1307.5	1626.0	1775.0	1412.0
11	1408.5	1212.0	1157.0	1344.5	1035.0	1241.5	1487.0
12	1587.0	1932.0	2022.5	1982.0	2554.0	2030.0	6096.0
13	1045.5	855.5	1213.0	1035.0	1153.0	1130.0	1477.0
14	1559.5	1379.0	1596.0	1348.0	1189.0	1763.0	2387.0
15	922.0	1029.0	1736.0	1018.5	1013.0	1113.0	1503.0
16	987.5	989.0	1102.0	942.0	1244.0	1215.5	1290.5
17	1119.0	931.0	945.0	1039.0	1217.0	1097.0	1001.0
18	1334.0	990.0	1895.0	1306.0	1076.5	1396.0	1821.5
19	909.0	1038.0	2083.0	1330.0	1393.0	1273.0	1452.5
20	1566.0	1438.0	1971.0	1135.0	1103.0	1104.0	2270.0
21	1038.5	1117.0	1132.0	1274.0	1296.0	1426.0	1098.0
22	1262.0	1258.0	1309.5	1244.5	1336.0	1393.5	1131.0
23	935.5	1209.0	937.0	1107.5	915.0	992.0	1106.0
24	905.5	699.0	791.0	701.5	724.0	972.0	841.0
25	828.0	870.0	845.0	978.5	942.0	844.0	848.0
26	1100.0	1132.0	1588.5	1060.0	1420.0	1509.0	1504.5
27	639.0	677.0	626.5	725.0	701.5	1053.0	903.0
28	757.0	701.0	716.0	804.5	956.0	728.0	686.0
29	2833.5	2583.0	1484.0	1911.0	1222.5	1295.0	1049.0
30	1051.5	961.0	1352.0	1171.5	1108.5	1177.0	1825.5

SUBJECT	C22	C23	C24	C25	C26	C27	C28
1	2901.0	3078.0	2705.0	2924.5	2417.0	3834.0	2735.5
2	848.0	1153.0	1047.5	1123.0	854.0	1323.5	1155.0
3	2275.0	2341.0	1462.0	1983.0	2245.0	1503.0	2456.0
4	2292.5	2039.0	2280.0	3073.0	1473.0	2837.0	2020.0
5	2656.0	2161.0	2370.0	2403.0	2283.0	2283.0	2231.0
6	1594.0	1374.0	1848.0	2186.0	2316.5	2373.0	1801.0
7	1315.0	1313.0	1873.5	2481.0	1288.0	2590.0	3256.0
8	2851.5	2835.5	2498.0	3032.0	2346.0	3065.0	1133.0
9	5287.0	6685.0	4169.5	7151.0	3488.0	7830.0	2682.0
10	1487.0	2482.5	1933.0	1540.0	2209.0	1940.5	2116.0
11	1391.0	1202.0	1429.0	1328.0	1261.0	1277.5	1661.0
12	2094.0	3003.0	2503.5	2211.5	2984.0	3088.0	1907.0
13	1091.0	943.0	1633.5	1360.5	1373.0	1315.0	1107.0
14	1217.0	1199.0	1455.5	1319.0	2165.0	1754.5	1644.0
15	1671.5	1390.0	1168.5	1472.0	1887.0	1587.0	1516.0
16	917.0	1079.0	1236.0	1295.0	918.0	1465.0	1071.0
17	1097.0	886.0	1087.0	1173.0	1039.0	1163.0	979.0
18	1103.0	1038.0	1358.0	1657.0	1123.0	1056.0	1605.0
19	1058.0	1056.0	1290.5	1824.5	1326.0	1207.5	1181.5
20	1505.0	1462.0	1125.5	1570.0	1879.5	1996.0	1709.5
21	1655.0	1119.5	1839.5	1956.0	1088.0	1279.0	1499.0
22	1125.0	1024.0	1143.5	1266.0	1162.0	993.0	1121.0
23	1016.0	1040.0	1227.5	877.0	996.0	1118.0	963.5
24	774.0	653.0	865.0	1076.0	868.0	729.0	1012.0
25	903.0	973.0	932.5	1315.0	705.0	1438.0	924.0
26	968.0	946.0	1278.5	1332.0	1091.0	1312.0	1589.0
27	1691.5	677.0	1112.0	845.0	722.5	909.0	911.0
28	813.0	657.0	717.0	1162.0	830.0	905.5	904.0
29	2499.0	1408.0	1969.0	2538.0	3142.0	1718.5	745.0
30	796.0	1015.0	1575.0	1028.0	957.0	979.0	1688.0

SUBJECT	C29	C30	C31	C32	C33	C34
1	2464.0	2409.0	2427	2381.5	2463.5	2617.0
2	481.0	642.5	913	768.0	630.5	1354.0
3	947.0	866.5	2293	958.0	1044.5	1057.0
4	887.5	862.0	928	998.0	914.5	1038.0
5	810.0	967.0	1337	759.0	1031.5	882.0
6	881.5	1023.0	1143	813.0	874.0	1050.0
7	847.0	840.5	1135	833.5	967.0	936.0
8	847.0	774.0	840	945.0	853.5	897.0
9	1274.0	1295.5	2220	2107.0	1788.0	2612.0
10	1007.5	1028.5	1403	1132.0	986.5	1593.5
11	1291.0	1156.5	1369	1260.0	1339.0	1793.0
12	1182.5	1176.5	1403	1242.0	1169.5	1721.0
13	987.0	1172.0	1387	1301.0	1042.0	1545.5
14	945.5	1069.5	1751	961.5	1173.0	1158.0
15	1007.5	762.5	1294	1273.0	1132.0	1411.0
16	1086.0	1065.0	1672	1199.5	1229.0	1724.0
17	839.0	910.0	960	867.0	919.0	1109.0
18	903.0	1002.5	944	1018.0	911.0	1545.0
19	756.5	1046.5	1315	1082.0	1159.0	1251.5
20	1063.0	1208.5	1216	1337.0	1256.0	1088.0
21	1222.0	1296.0	2131	1238.0	1322.0	1805.0
22	1038.5	853.0	1034	993.0	1109.0	906.0
23	1014.0	951.0	1025	948.5	973.0	1466.0
24	777.5	861.0	718	900.5	987.0	1099.0
25	840.0	839.0	951	915.5	742.5	849.0
26	1012.0	1187.0	1174	1127.5	1055.5	1925.0
27	712.5	763.0	941	845.0	818.0	849.0
28	690.0	470.0	832	786.0	850.5	866.0
29	1076.0	1285.5	1376	1471.0	1457.5	3592.0
30	782.5	943.5	1032	916.0	1062.0	836.0

EXPII BREAKDOWN OF CONDITIONS (C1-C10).

CND	COM	REP	AL
1	ID-2	RADJ	IR
2	ID-2	RADJ	INR1
3	ID-2	RADJ	INR2
4	ID-2	REND	IR
5	ID-2	REND	INR1
6	ID-2	REND	INR2
7	ID-2	RCON	====
8	IN-1	RADJ	====
9	IN-1	REND	====
10	IN-1	RCON	====

EXP II MEDIAN DATA POINTS USED IN ANOVA
(S1-S20) HIGH LOADING, (S14-S20) LOW LOADING ON FACTOR 1.
15:58 THURSDAY, MARCH 10, 1977

SUBJECT	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
1	1514.0	1409.5	1298.0	1175.5	1463.0	1172.5	1213.0	987.5	1063.5	1003.0
2	2271.0	2632.0	1785.5	2009.0	2173.0	1667.5	2020.5	950.0	943.0	1080.0
3	1770.0	1648.0	1389.5	1831.0	2062.0	1512.0	1826.0	1043.0	1136.0	1113.0
4	2041.0	2191.0	2236.0	2411.0	3542.0	1911.0	2745.0	1064.5	1008.0	937.0
5	2270.5	1580.5	1675.0	1794.0	1281.0	1132.0	1812.5	942.5	829.0	969.0
6	3136.5	2759.0	2746.5	2767.0	2632.0	2928.5	3498.0	1100.0	1073.0	1100.5
7	1497.0	1630.0	1142.5	1787.0	1663.5	1683.5	1512.0	1029.0	1034.5	968.0
8	1876.0	1698.0	1365.0	2048.0	1638.0	1476.0	1635.0	662.5	659.0	760.0
9	1525.5	1672.0	1818.5	1765.5	1464.5	1384.0	1694.0	942.0	1058.0	949.5
10	1639.5	1621.0	1477.0	1354.5	1490.5	1407.0	1561.5	902.0	781.0	782.0
11	1596.0	1598.0	1203.5	1372.5	1171.0	1548.5	1527.5	862.0	872.5	857.0
12	2110.5	2068.0	1698.0	2109.5	1887.0	2414.5	2002.5	900.0	991.5	891.5
13	1357.0	1435.0	1163.0	1506.0	1437.5	1306.0	1500.5	877.0	970.0	969.0
14	1763.0	1487.5	1815.0	2135.0	1552.5	1612.0	1538.0	1197.5	1149.5	1318.0
15	1157.0	1505.0	1198.5	1188.0	1412.0	1754.0	1465.5	1174.0	1048.0	1149.0
16	1127.5	1295.5	1195.0	1407.0	1959.0	1756.0	1446.5	1045.5	1082.0	1274.5
17	1389.0	1194.5	1231.5	1821.0	1442.5	1518.0	1485.5	1121.0	1179.0	1140.0
18	1379.0	1427.5	2661.0	1632.0	1629.5	1324.5	1573.5	582.5	774.0	928.5
19	966.0	938.0	1865.0	988.0	1423.0	1167.0	1275.5	999.0	990.0	977.0
20	1096.5	1208.0	1624.0	1306.0	1196.0	1198.0	1217.0	946.0	1120.0	908.5

EXP III   BREAKDOWN OF CONDITIONS (C1-C14).

CND	COM	REP	AL
1	ID-2	RADJ	IR
2	ID-2	RADJ	INR1
3	ID-2	RADJ	INR2
4	ID-2	REND	IR
5	ID-2	REND	INR1
6	ID-2	REND	INR2
7	ID-2	RCON	====
8	ID-2	RSEP	IR
9	ID-2	RSEP	INR1
10	ID-2	RSEP	INR2
11	IN-1	RADJ	====
12	IN-1	REND	====
13	IN-1	RSEP	====
14	IN-1	RCON	====

SUBJECT	C1	C2	C3	C4	C5	C6	C7
1	1227.5	1184.0	1081.0	1030.0	1018.5	843.0	1364.0
2	1630.0	2000.0	1513.0	1827.0	1351.5	1195.0	1537.5
3	1991.0	2071.0	1713.5	2170.0	3456.0	2032.0	3521.0
4	2214.0	2478.0	2413.0	2540.0	2089.0	2865.5	2711.0
5	1816.0	2229.0	1935.0	1973.0	1534.0	2311.5	2462.0
6	1277.0	899.0	1820.0	886.0	1149.0	1101.0	1351.0
7	1119.0	974.0	1816.0	867.0	1204.0	1215.0	1113.0
8	1501.5	1567.5	1741.0	1489.5	2025.0	1734.0	2182.0
9	1173.5	1086.5	1099.0	1116.5	1457.0	1144.0	1480.0
10	3062.0	2315.0	2093.0	2738.0	2513.5	2585.0	5571.0
11	3330.5	3074.0	3457.0	3232.5	3307.0	3219.0	3746.0

SUBJECT	C8	C9	C10	C11	C12	C13	C14
1	1789.5	1149.5	1513	1122.0	957.0	1317.0	1165.5
2	1453.0	1536.5	1956	972.0	892.5	1033.0	847.0
3	2015.5	2089.5	3381	1087.5	1068.0	1021.0	1083.0
4	2361.5	2778.0	2539	1384.5	1383.5	1258.5	1405.0
5	1815.0	2800.0	2384	1367.0	1513.0	1136.0	1298.0
6	1434.0	1732.0	1429	981.5	1077.5	1410.0	1137.0
7	507.5	1094.0	1520	1079.5	1258.5	781.0	1115.5
8	2258.0	1899.0	1864	819.0	829.0	750.5	858.0
9	1184.5	1457.0	1256	1175.0	1116.0	1415.0	1187.0
10	3457.0	2833.0	2918	975.0	987.0	670.0	902.0
11	3525.0	3606.0	3157	1738.5	1557.0	1785.0	1532.0

Vita

Date of Birth:	July 30, 1952
Place of Birth:	New Brighton, Pennsylvania
Home Address:	540 Jackson Street Rochester, Pennsylvania 15074 (412) 774-0749
Higher Education:	Slippery Rock State College 1970-1974, B.A. Psychology V.P.I. & S.U. 1974-1977, M.S. Psychology
Professional Experience:	Teaching Assistant V.P.I. & S.U., 1974-1977
Professional Affiliation:	Member of: Psi Chi (Psychological Honorary) Human Factors Society American Institute of Industrial Engineers (AIIE) American Association of University Professors (AAUP)

Richard C. Cordes

Intraserial Repetition Effects upon Levels of Cognitive Processing

by

Richard E. Cordes

(Abstract)

The effects of intraserial repetition were tested using a probeless memory search task. Reaction time was facilitated in Experiments II and III only if the task involved alphabetical comparisons suggesting that repetition affects a comparison stage.

The results of Experiment III revealed that the location of an item and its repeat in the set is an important variable since repetition effects were found only if the item and repeat were adjacent in the set. The results were supportive of an information reduction model in which stimulus sets containing repetition are reduced. Set reduction occurs more readily for the adjacent repetition condition due to the identical items being perceptually distinct. Support for a trace strength model prediction that only repeated target letters would facilitate RT was not found.