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(Signature)
Dr. Donna Fay Cruse

This experiment used a choice recognition time task. The subjects task was to decide whether a probe tone was or was not among a presented set of one to four tones. One of three cue conditions occured on each trial: the cue (a light) was presented immediately following the tone to-be-forgotten; simultaneously with the tone to-be-forgotten; or not at all. Results indicate that the recognition (and decision) time was a linear function of the number of tones not cued rather than the total number of tones presented. These findings suggest that non-verbal auditory itmes may be intentionally forgotten, although, an alternate interpretation considered was that the tones may have remained in memory and the subjects selectively scanned and compared only the non-cued tones with the probe.

Cued forgetting of tones; Intentional forgetting of non-verbal items

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Richard Alan Jones

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APPROVED:

Redacted for privacy

Assistant Professor of Psychology

Redacted for privacy

Associate Professor of Speech Communication

Redacted for privacy

Professor of Statistics

Redacted for privacy

Dean of Graduate School

Redacted for privacy

Head of general Studies

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Typed by Claudia Nichols for Richard A. Jones

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Previous studies (eg. Bjork, 1970) have reported that when subjects are instructed to forget certain items from a list, the retention of the remaining items is improved. Typically, the procedure involves presenting a cue at some time after the presentation of the item that is to be forgotten which usually is an instruction to the subject that he will not be tested on that item and is to forget it. Bjork (1970) has proposed three explanations for the results of intentional forgetting: (1) the cued items are actively erased or dumped from memory resulting in a reduced memory load; (2) at the time of the cue there is no further processing or rehearsal of the items, therefore they are lost; (3) the subjects are able to differentiate the items into separate sets which do not interfere with each other. Bjork contends that a combination of the latter two explanations are responsible for the increased retention of the items which were to be remembered. That is, the subjects first differentiate the items into separate sets and then rehearse only those items that are to be remembered.

Several other studies have suggested that rehearsal is a major influence on the intentional forgetting effects (Turvey and Wittlinger, 1969; Elmes, 1969; Reed, 1970; Bruce and Papay, 1970). The cited experiments have used visually presented words or trigrams as stimulus materials in both recognition and recall tasks with the number of correct responses being the major dependent variable. It should be noted that although some studies have used a shadowing task to curb rehearsal (Block, 1971; Elmes, 1970), the results are not conclusive as to the exact role of rehearsal in intentional forgetting.

The present experiment is also concerned with intentional forgetting, and with the processes (including rehearsal) that are involved. However, the paradigm differs considerable from those mentioned previously. This experiment utilizes a modification of the Sternberg (1969) memory scan paradigm from which the recognition time can be used to infer the number of items in immediate memory.

The Sternberg (1969) paradigm consists of presenting a few items (positive set) from a memorized set and then, after a short delay, the subject is presented with a probe item. The subject is to indicate whether the probe item was among the set presented. The recognition time (RT) of the decision is found to increase linearly with the set size, indicating that the search process is exhaustive. That is, the probe is compared with all items in the set before a decision is made. It is also found that RT does not differ as a function of the position of the probe in the memorized set, which also is indicative of an exhaustive process. Regardless of interpretations of the search process, RT is an increasing function of the number of items in the set. This paradigm which uses tones as the stimuli was chosen for three major reasons: (1) to determine if intentional forgetting may be established in the auditory as well as the visual processing system; (2) to investigate a second dependent variable, choice recognition time, to infer the number of items in memory; (3) and to provide a further test of the hypothesis that a rehearsal factor is responsible for the forgetting effect, since instructing subjects to rehearse does not result in an improvement in recognition memory for pitch

(Massaro, 1970; Wickelgren, 1969).

It is predicted that when none of the items in the memory set are cued to be forgotten, RT will be a linear function of the number of items in the set. Further, if some of the items are cued and forgetting is effective, then the RT is expected to be a function of the number of items not cued rather than a function of the total number of items presented. Alternately, if cueing to forget has no effect, then the RT should be a function of the total number of items presented.

The previous predictions are dependent upon the assumptions that on each trial the subject is able to assimilate the cues, and that the presence of the cued tone prior to forgetting is not detrimental to the memory of other tones in the set. Evidence for this possibility is provided by Massaro (1970), who found that when either Gaussian noise, or tones were inserted between a standard and a comparison tone, they were both more detrimental to recognition performance than was a blank interval. These findings were attributed to interference. In order to control for the possible influence of the above factor, a condition of presenting the cue simultaneously with the tone to be forgotten was included for comparison. In addition, this cue during condition served to equate the overall time intervals between the tone that were to be remembered and the probe with the cue after condition. It seems reasonable to expect that cueing to forget after the item was presented could not produce more forgetting than if the subjects knew at the time of presentation that they were to forget that item.

METHOD

Subjects.– The five subjects (Ss) used in the experiment, four males and one female, were employees of the Psychology Department at Oregon State University. Each S received a score based on his speed and accuracy; 12 points were gained for every correct RT under 500 msec. and 40 points were lost for every incorrect choice. Prior to the experimental sessions each subject had at least one full session for practice in order to meet a requirement of less than 10% errors.

Apparatus.– A Digital Equipment Corporation PDP-12 computer controlled the experiment and generated the eight square wave tones that were used as stimuli and recorded the data. Separate volume controls were provided for each ear so that the subject could adjust the intensity to his own most comfortable listening level. Two telegraph keys were used for responding and were built into a console that was placed on a table in front of the subjects. Directly above each key was a feedback light used to indicate which response was correct. Centered between the response keys and the feedback lights was a light emitting diode which provided the cue for the forget instructions.

Procedure.– Each subject participating received ten daily sessions of 20 practice trials followed by three blocks of 76 trials each. On each trial a variable set of 1, 2, 3, or 4 tones (positive set) was presented and was followed by a probe tone. These tones were chosen randomly from the set of eight tones and they varied from trial to trial. The frequencies of the eight tones were derived by dividing the range of 259 Hz to 2.59kHz into subjectively equal ratios. The intertone intervals, the tone durations, and the cue durations were all 500 msec. each, while the interval between the probe tone and the last tone in the set was 1200 msec. On half of the trials the probe tone was a member of the positive set (positive probe), and on the other half the probe was not a member of the positive set (negative probe). The negative probe was chosen randomly from the remaining tones. For each trial, one of the three cue conditions occurred: the cue was presented immediately after the tone to be forgotten (cue after), the cue was presented simultaneously with the tone to be forgotten (cue during), or none of the tones were cued (none cued). For both of the conditions in which cues were presented the number of tones cued was varied: set size four had 1, 2, or 3 tones cued, set size three had 1 or 2 tones cued, and set size two had one tone cued. An equal number of trials with none cued was included for each respective set size In addition, set size one was only included in the none cued condition. This design resulted in 38 conditions, each of which occurred twice in a block with their order randomized for each block. Both the position of the probe and the position of the cued tones were completely random within the positive set.

The subjects were given a general description of the task along with instructions to forget the cued tones, and they were informed that the probe would not be one of these cued tones. Three of the Ss were instructed to respond to a positive probe with their preferred hand and two were to respond with their non-preferred hand. Responses to negative probes were made with the opposite hand. The Ss were told to respond as quickly and as accurately as possible, and they were informed by feedback lights which response was correct.

The PDP-12 computer printed, via teletype, the subjects' score, the number of errors, and the mean RT after the practice trials and after each block so that the subjects could be aware of their progress. At the end of each session, the RT, which was measured from the onset of the probe to the response, was recorded onto paper tape which later was transferred to Hollerith cards for analysis.

RESULTS

Error Analysis

The overall proportion of trials which contained errors was 6.5%. For the none cued condition the error rates for set sizes 1, 2, 3 and 4 were 2.0%, 3.3%, 5.5% and 10.0% respectively. Pooled over number of cued and set size (2-4), the rates for none cued, cued during and cued after for negative probes were 6.6%, 7.2% and 7.9% respectively; for the positive probe condition, the rates were 8.3%, 4.9% and 5.7% respectively. On 0.4% of the trials, RT was either less than 125 msec., or greater than 2000 msec. These, as well as response errors, were not included in the subsequent RT analyses.

Reaction Time Analysis

The mean recognition time was computed for each subject for each block of five days, and for each experimental condition. An analysis of variance was first performed on all of the data pooled over set sizes 2, 3, and 4. The main effect of cue condition was significant, $F(2,8) = 11.754$, $p < .01$, with the mean RTs for none cued, cued during and cued after, of 416.4 msec., 382.3 msec., and 391.5 msec. respectively. That is, there was an average decrease in RT in comparison with the none cued condition, of 34 msec. per tone (cued during) and 25 msec. per tone (cued after). The probe type effect and the probe by cue interaction were also significant, $F(1,4) = 215.27$, $p < .01$, and $F(2,8) = 6.522$, $p < .05$.

In order to examine the effect of set size, an analysis of variance was performed on the data from the none cued condition, and the "all cued but one" conditions of the cue during and cue after cases. The mean RTs, as a function of cue condition, probe type and set size, are presented in Figure 1 where the mean RTs for none cued are those from the entire sample. The RTs are pooled over blocks since this effect did not reach significance, $F(1,4) = 7.331$, $p > .05$.

Figure 1 about here

The main effect of probe type was significant, $F(1,4) = 142.66$, $p < .01$ indicating that RT for positive probes was faster than for negative probes, although this variable was confounded with hand preference because of the inherent inadequacy of counterbalancing with five subjects. The main effect of set size was highly significant, $F(2,8) = 49.439$, $p < .01$, as illustrated in Figure 1 by the fact that all curves are monotonically increasing as a function of the number of items in the positive set. The interaction between probe type and set size failed to reach significance, $F(2,8) = 2.74$, $p > .05$, supporting the exhaustive scan models prediction that positive and negative RTs are parallel functions of set size.

The overall effect of Cue was significant, $F(2,8) = 18.007$, $p < .05$, with the mean RTs for the condition of none cued, cued during and cued after 410 msec., 350 msec., and 364 msec. respectively. Considering that there was an average of two tones cued per trial in the cue during and cue after conditions, in comparison with the none cued condition, there was then an average decrease in RT of 30 msec. per tone for the cued during case, and 23 msec. per tone for the cued after case. This

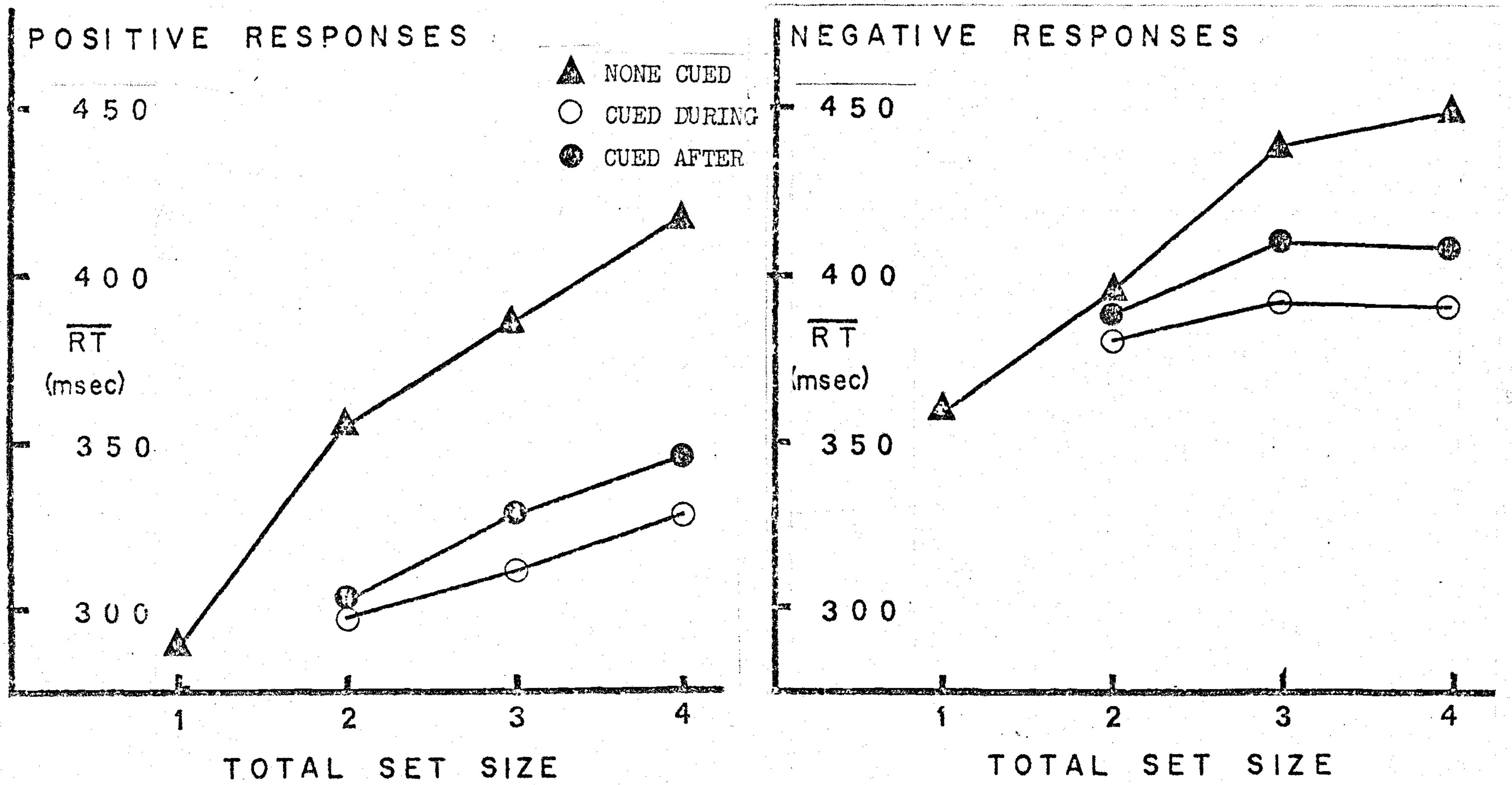

Figure 1. Mean recognition time (RT) as a function of cued condition, response type and set size. The cue during and the cue after conditions represent the all cued but one case.

provides durect support for the hypothesis that the cueing to forget instruction were effective.

The cue condition by set size interaction was also significant, $F(4,16) = 4.57$, $p < .05$, indicating that the number of items scanned in the cue during and cue after conditions was less than in the none cued case. This provides additional support for the hypotheses that cued tones were not scanned. Figure 1 also illustrates an interaction between probe type and cue condition, $F(2,8) = 6.38$, $p < .05$. This differential effect presents a problem for the unconditional conclusion that the tones that were to be forgotten were no longer in memory. That is, it appears that there was more effective forgetting of cued tones in the positive probe case than in the negative probe case. An explanation for this finding is not immediately obvious, since it is logical that a tone would be forgotten at the time of decision regardless of the decision that was made.

This probe type and cue condition interaction effect is also apparent in Table 1 which presents the linear regression estimates and their standard errors for the data composed in Figure 1. In the

Table 1 about here

positive probe condition, the intercepts of the three cue conditions are quite similar while the negative probes show a larger difference. However, an examination of the slopes indicates that the slopes of the negative probes are much closer to zero than those of the positive probes, indicating a differential effect for both parameters.

Table 1. Linear regression estimates and their associated standard error (S.E.).

	RESPONSE			
	POSITIVE		NEGATIVE	
CONDITION	INTERCEPT	SLOPE	INTERCEPT	SLOPE
NONE CUED	259.6	41.2	332.0	31.3
S.E.	16.5	6.0	14.2	5.2
CUE DURING	268.8	14.6	372.4	5.1
S.E.	0.9	0.3	13.7	4.4
CUE AFTER	263.3	20.9	373.5	9.4
S.E.	5.4	1.7	23.5	7.6

The linear regression on set size for none cued positive and negative probes were found to remove a significant amount of variance, $F(1,2) = 46.83$, $p < .05$, and $F(1,2) = 36.858$, $p < .05$, which generally supports a serial scan; however, the cue during linear regression was also significant for the positive probe, $F(1,1) = 2557.4$, $p < .05$, indicating that there was a linear component as a function of set size for this condition. The remaining regressions failed to reach significance as would be expected if RT was not a linear function of the total number of tones presented.

In Figure 2 the mean RT is shown for each set size as a function of the position of the probes for the none-cued condition. The recency effect evidenced in this figure was also apparent for the all cued but one case (not shown). A comparison of these serial position curves

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Figure 2 about here

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indicates that the RT for the set size one (none cued) case, 270 msec. is essentially the same as the average RT for the last item in all set sizes for the other two cue conditions (284 msec.).

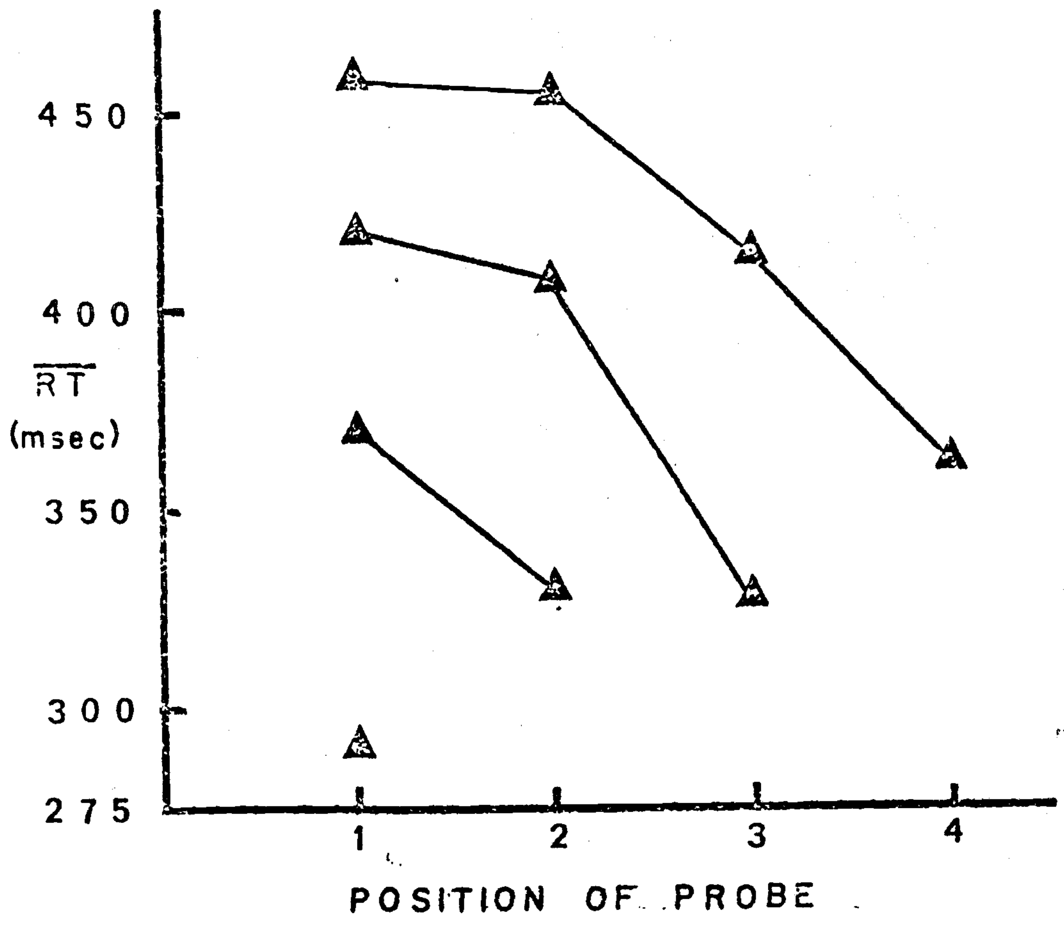

Figure 2. Mean recognition time as a function of set size and of the position of the probe tone for the none cued conditions.

DISCUSSION

The main cue effects in the analysis of variance provide support for the prediction that the tones that were to-be-forgotten were forgotten. This was evident by the decreased RT when some of the tones were cued and, by the interaction of the cued conditions with set size which indicates that the effects of set size were not the same for all cue conditions. This was supportive to the finding from the linear regressions that the RT was a linear function of the total number of tones in the positive set for the none cued case but, not in general, a linear function of the total number of tones when all but one of the tones were cued. The results also show that the cue presented during the presentation of the tone differs consistently from the cue being presented after the tone only by a slight increase in performance denoted by a more reduced RT.

The interaction between the cue conditions and probe type presents some evidence for a case that the items were not forgotten but instead were stored in a different set, and thus, supporting a differential search hypothesis such as that proposed by Bjork (1970). If the tones no longer existed in memory then they could not be expected to interact with the type of probe. Although a differential effect between none cued and cued conditions was quite apparent as a function of the probe for both slopes and intercepts, there was also a difference in the slopes and intercepts for the none cued conditions as a function of the probe. It seems possible that whatever is constituting the underlying differences in probe type for the none cued case, may also be producing a greater effect for the cued to forget conditions in which supposedly some of the items are removed.

Previous experiments by Reitman et al. (1971) provided rather strong evidence that a differential search hypothesis was responsible for their intentional forgetting results. In this cueing to forget paradigm, which was quite similar to Bjork's (1970), the cues that were given as the forget instructions were also given just prior to a probed recall of words that were to have been forgotten. Substantial retention of forgotten items was found. Epstein & Wilder (1972) found similar results by simply informing the Ss that they were being tested on to-be-forgotten words. Further evidence is supplied by Woodward & Bjork (1971) who, at the end of a recall test for retention, instructed the Ss to make a final recall of all the words they could remember regardless of whether they were instructed to forget them and gave a bonus for any word they could recall. After they listed the words they then circled those they thought were words that were to be forgotten. The results indicated a considerable recall of the words that were to be forgotten although words recalled were in general labeled as words that were to be remembered whether in fact they were words to be remembered or words to be forgotten.

Because of the vast differences between the paradigms of the preceding experiments and the present experiment, different factors will have to be considered in order to interpret the results with respect to the differential search hypothesis. Specifically, if the tones had been differentiated into two sets (cued and none cued), then a hierarchial search process such as the one propesed by Clifton & Gutschera

(1970) might be expected. These authors also employed a choice recognition time paradigm, and their hypothesis, which was generally supported by their results, states that the subjects first select the appropriate set and then scan within the selected set for the probe item. This hypothesis makes the prediction that the intercepts of the RT functions for lists that have two sets should be displaced upwards above the intercepts for lists that have only one set. Such an increase was found for the negative probes but not for the positive probes. If this set selection was made only for the negative case, then it would be expected that the cueing would be effective for the positive probes. Clearly, the results from this experiment do not fully support this interpretation.

The model on which Clifton and Gutschera based their hypothesis derived from a serial exhaustive model, therefore it is important to consider the implications of the results from the present experiment to this model. In general, the results provide support for s serial exhaustive scan with the possible exception of the recency effect. That is, the prediction of the model that RT will not vary as a function of the probe position was not supported; however, this finding is not necessarily irreconcilable with modifications of the general models. The research summarized by Sternberg (1969), in support of the model, utilized visually presented material for stimuli. One explanation suggested for the lack of a serial position effect was that the Ss may have been rehearsing the items. Sternberg attempted to curb rehearsal by inserting another task between the items in the positive set and the probe which resulted in an increase in slope. From this finding it was inferred that there was an inactive memory and an active memory that utilized rehearsal. This recency effect possibly indicates that Ss were not rehearsing the tones in the positive set.

It may be argued, however, that the recency effect found in these results was due to a self-terminating scan which started at the last tone in the positive set, continued towards the first tone presented, and stopped if a match was made. Not only does this strategy sound implausible, but a self-terminating search should result in a lower slope for the positive probes than for the negative probes, when, in fact, the slope for the positive probe case was actually higher. It would certainly seem more reasonable to assume that this effect was due to a differential measure to strength associated with decay and/or interference. While it may be possible to corporate these finding within a serial exhaustive model, parallel processes could also be considered.

CONCLUSIONS

The finding that cueing-to-forget tones resulted in a decrease in recognition time for this task provides support that intentional forgetting may be demonstrated with non-verbal auditory items as well as visual verbal items. The paradigm used avoided relying upon verbal responses to determine the number of items in memory. The results show some residual retention and a comparison of the cue during and cue after conditions allowed for the possibility that the residual retention may be due to factors produced by the presentation of the tone rather than by its storage.

With respect to the two hypotheses of differential search and differential rehearsal of the none-cued tones, the findings also cast considerable doubt that rehearsal was the major factor for intentional forgetting. What seemed like a reasonable indicator of a hierarchial search of a combined cued and none cued set, was not consistently found, and although this was not proof against the differential search hypothesis, it does provide additional support that the tones were forgotten.

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