NOISE EFFECTS ON RATE OF REHEARSAL IN SHORT TERM MEMORY

A thesis submitted to the
University of London for the degree of
Doctor of Philosophy

by

NARESH KUMAR MOHINDRA

University of London
Bedford College
January 1983

ABSTRACT

Chapter 1 reviews the literature on the effects of noise within three memory paradigms. This review shows a general trend indicating that noise increases reliance on order information.

Chapter 2 thus attempts to establish a relationship between the recall of order information and the use of phonological coding and suggests that noise, in some way, interferes with the efficiency with which phonological codes are used.

Chapters 3 - 6 then describe ten experiments carried out to test this hypothesis. Experiments 1 - 4 showed that noise improved serial order recall of acoustically similar letters and that noise effects were more likely to be observed in conditions where rehearsal depended on some internally stored representation rather than being guided by visually available items.

Experiments 5 and 6 investigated the effects of noise on a recognition and a free recall task and generally found no effects.

Experiments 7 and 8 showed that overt rehearsal of items in noise was slower. Experiment 9 then showed that slowing of rehearsal had different consequences on memory performance depending on the spoken length of the to-be-remembered items. A model was described to explain the improvement in recall of acoustically similar items presented in noise, as well as the impairment in recall of dissimilar items

and of words of long spoken length.

Experiment 10 showed that retrieval of phonological codes was impaired by noise while no effects were observed on the retrieval of semantic codes. This was suggested as being responsible for the preference which subjects show for adopting maintenance rehearsal strategies, which may in turn produce the effects observed in noise of improvement in order recall but impairment in semantic processing.

The final chapter integrates the above evidence in an attempt to explain the strategic nature of noise effects on memory performance.

ACKNOWLEDGEMENTS

First of all I would like to thank my parents for being open minded and encouraging me to pursue a course of study of my own choosing.

I am also extremely grateful to Dr. John Wilding, firstly for allowing me the opportunity to work with him,and secondly for his dedication and unfailing encouragement in supervising the research presented in this thesis.

Also I would like to thank all the staff in the Psychology Department at Bedford College who, all contributed not only to my work, but also to making the time I spent there totally rewarding and very enjoyable.

Also I am indebted to numerous students attending Bedford College who freely volunteered to participate in the experiments and to many postgraduate friends particularly Shahidul, Daljit, Ray, Marie, Bessie, Kris, John-M-S, Luke, Shashi and Tony from all of whom I learned a great deal.

Finally, I especially want to thank my wife Sandhya, my sister Veena and my brother Raju who were always there to help when ever I needed them.

Our scientific world is our world of reasoning. It has its greatness and uses and attractions. We are ready to pay the homage due to it. But when it claims to have discovered the real world for us and laughs at the worlds of all simple-minded men, then we must say it is like a general grown intoxicated with his power, usurping the throne of his king. For the reality of the world belongs to the personality of man and not to reasoning, which is useful and great but which is not the man himself.

Rabindranath Tagore.

TABLE OF CONTENTS

NOISE EFFECTS ON MEMORY

PHONOLOGICAL CODING AND THE RECALL OF ORDER INFORMATION IN SHORT TERM MEMORY

NOISE EFFECTS ON SHORT TERM SERIAL ORDER MEMORY

EXPERIMENTS 1 - 4

THE EFFECTS OF NOISE AND TEST EXPECTATIONS IN RECALL AND RECOGNITION

EXPERIMENTS 5 & 6

CHAPTER 1

THE EFFECTS OF NOISE ON MEMORY

1.1 Introduction

Over the past twenty years a growing body of findings has emerged from investigations of the effects of mild stress on memory performance. Numerous stress-inducing variables, for example white noise, heat, sleep deprivation, muscle tension, vibration etc. and non-stressful variables, for example time of day and personality, have been used, in a multitude of experimental paradigms, in order to discover how memory performance is affected by exposure to different intensities of a single variable, or exposure to a combination of variables.

Several explanations have been advanced for the findings; the most popular suggests that stressors affect performance through a change in the individual's state of arousal. An inverted U function, first demonstrated by Yerkes and Dodson (1908), has been hypothesised as being descriptive of the action of stressors, with performance deteriorating as a result of either under or over arousal and optimum performance occurring at intermediate levels of arousal.

Recently, however, researchers have become dissatisfied with general explanations couched in terms of the arousal model. A number of criticisms have been levelled against this model; firstly difficulties concerning the measurement of arousal have been encountered. It has been shown that peripheral indices of arousal such as heart rate, galvanic skin response and muscle action potentials are by no means interchangeable and that correlations between measures are correspondingly low (Lacey, 1967; Taylor 1967). Lader (1975) suggests however that low correlations may be obtained partly because various indices are differentially responsive over different ranges of arousal, for example heart rate is more sensitive over the high and galvanic skin response over the low range. A second problem which has been encountered has been that of the patterning of the autonomic response. Two factors are seen to be involved: situational and individual. Situational factors are seen to be stimulus specific, individual factors are seen as being response specific. Therefore any change of arousal in an individual at any given time represents an interaction between these factors.

In general therefore difficulties in formulating clear predictive theories about the effects of arousal have led explanations to be descripitive in nature, rather than being able to specify precisely any of the mechanisms involved.

Another explanation which also holds a certain amount of popularity has been the cue-utilization hypothesis of Easterbrook (1959). This states that as arousal increases the range of cues attended to in performance decreases, resulting in a focussing or a narrowing of attention. This type of approach also has its disadvantages, since it also incorporates the concept of arousal. However it can be seen as the forerunner of more recent alternatives which have tried to move away from the concept of arousal and have suggested instead, in cognitive terms, precisely what happens when individuals are exposed to stressful and non stress-inducing conditions. It is suggested that memory performance reflects changes in memory strategy, which may occur in the presence of the stressor. Thus individuals are seen to be exercising an active control over their response by adopting task-relevant strategies in order to maximize performance under the given experimental conditions.

This type of explanation raises the problem of why non stress-inducing stimuli should produce changes in memory strategy since the subjects in these experiments would be unaware of their presence. It could however be argued that these changes in strategy are perhaps automatic and are not necessarily under the direct control of the subject.

In any event a detailed investigation of the changes in strategy which occur under experimental manipulation of stress-inducing stimuli, and the cause of such changes, seems warranted and this is what will be attempted in this thesis.

The aim of the rest of this chapter is to review, selectively, experimental evidence which highlights the strategic nature of the effects of different stressors on memory performance. In this respect noise has been the most consistently studied stressor (mainly because of the ease with which it is manipulated) and although the majority of this review will be confined to studies investigating the effects of noise on memory performance, the results of other stressors will be discussed in order to point out the differences and similarities between their effects and those of noise.

The experiments discussed in the review can be classified as emerging from the use of three major memory paradigms: those requiring paired associate recall, those requiring free recall and finally those requiring serial order recall. This review shows that although there is a great deal of inconsistency in the evidence there is a general trend indicating that noise increases subjects' reliance on order information.

The second chapter thus attempts to establish the existence of a relationship between the recall of order information and the use of phonological coding and suggests that perhaps noise, in some way, interferes with the efficiency with which phonological codes are used. This reduction in efficiency may be responsible for the preference which subjects show for adopting a maintenance rehearsal strategy which may in turn produce the effects observed on memory performance in noise.

Chapters three to six then describe experiments carried out to test the above hypothesis. The effects of noise on serial order recall, on recall given different test expectations, on rate of rehearsal and finally on the process of phonological coding itself are outlined.

The final chapter then attempts to integrate this evidence and tries to explain the strategic nature of noise effects while emphasizing the relationship between changes in strategy and the resulting memory performance.

1. 2 Experiments Utilizing the Paired-associate Learning Paradigm

Research in the early sixties concentrated on investigating the relationship between electrodermal activity and subsequent recall. The concept of the inverted U function,as elaborated by Hebb (1955) and Malmo (1958), supported the position that measures such as Galvanic Skin Response (GSR) were the best indices of activation or general arousal.

The interaction between arousal and retention interval.

Kleinsmith and Kaplan (1963, 1964) and Walker and Tarte (1963) examined the relationship between the arousal level associated with a stimulus and the extent to which that stimulus will be remembered. Each of these studies chose items to be learned which produced either high or low arousal as measured by the amplitude of the GSR evoked by the items. Kleinsmith and Kaplan (1963) paired the words Kiss, Rape, Vomit, Exam, Dance, Money, Love and Swim with the digits two through nine, and subjects were given one presentation of each stimulus word followed by the word paired with the corresponding digit. The amplitude of the GSR for each stimulus word was measured and the eight words were then ranked in ascending order of evoked GSR. Measures of recall obtained after an immediate test and after tests carried out at varying delays of up to one week showed that high arousal items were associated with poorer short-term (2 mins.) and better long-term recall (1 week).

Similar results were found by Kleinsmith and Kaplan (1964) and Walker and Tarte (1963) and were explained in terms of

Walker's (1958) theory of action decrement. According to this theory high arousal during the associative process results in a more intensly active trace which produces temporary inhibition (action decrement) against short term recall, but one which results in greater long term memory. Some support for this position has also been reported by Berlyne, Borsa, Craw, Gelman and Mandell (1965); Berlyne, Borsa, Hamacher and Koenig (1966) and by McLean (1969) who all manipulated arousal independently of the meaning of the stimulus items by presenting some groups of subjects with white noise at different times during learning and recall. In the Berlyne et al., (1965, Expt. 3) study 75dB white noise was presented for some of the items at learning only or at recall only. It was found that after a recall interval of 24 hours, items learned under exposure to white noise were recalled significantly better than non- white noise items. Immediate recall however was significantly less for items learned under white noise compared to the non-white noise items. Noise when presented at the recall stage however, had no effects on performance. McLean's (1969) study also showed that high arousal items (i. e. those items presented in white noise), relative to lower, showed poorer short-term recall and better long-term retention. and again the interaction between noise level and retention interval was significant. A number of studies however, have failed to find such an interaction. Berlyne et al., (1966) showed that although white noise presented at learning increased recall in a test trial given 24 hours later, it had no detrimental effects on immediate recall. Schonpflug (1966) employing a continous tone, absent or present during learning, found that high arousal items, relative to lower, showed better short (2 mins.) and long-term (45 mins.) retention. The interaction of arousal and retention interval again not being significant.

Haveman and Farley (1969) in an attempt to extend the Berlyne et al., (1966) study employed CVC nonsense syllable pairs presented under 75 dB white noise and found that the prediction that white-noise-induced arousal would increase long-term recall did not receive confirmation. The only result consistent with the Berlyne et al., (1966) experiment was that white noise did not impair immediate recall. Haveman and Farley suggest that a failure to find a significant difference in either condition (i.e. in long term or short-term) may have been a result of "floor effects" with subjects not showing an adequate amount of learning to test the hypothesis under consideration.

In summary then, the experiments reviewed so far consistently show that high arousal, either in the form of evoked GSR or induced by white noise, leads to an improvement in long-term recall. The results for short term recall are however not so consistent. Five studies showed the result of poorer recall, two showed no effect of noise on short term memory and one study (Schonpflug, 1966) showed that short term memory is better for high arousal items. This inconsistency was also noted by Hockey (1977) and prompted him to suggest that "one of the principal limitations in the generality of the impaired short term memory conclusion concerns the use of the paired-associate task itself".

This difficulty is highlighted in an experiment carried out by Hamilton, Hockey and Quinn (1972) where a conventional paired-associate task (in which the order of the stimulus pairs was randomised from study to test trials) was compared to one in which the order was kept constant. The results showed that when order of items in lists was maintained over successive anticipation trials, short term recall was improved in 85 dB as compared to 55 dB noise conditions. This result could of course be specific to noise; though Fowler and Wilding (1979) did get it with incentives, there are no other replications using other arousers. On the conventional task, Hamilton et al. found that noise impaired recall and suggested that this result was due to subjects making more use of order information in the noise state. Moreover it was suggested that the effect of noise leads to a change in the way in which information is processed in the task, rather than simply altering the efficiency of learning. Hockey (1977) further suggests that although the results showing improved long term recall for items learned under high arousal are generally consistent, this high agreement may also be an artifact of the kind of tests that have been used to measure long term recall. He observed that: "Almost every study in which this result is found is of the kind which Tulving (1972) identifies as depending on episodic memory". Episodic memory refers to the storage of particular events and episodes with items being expressed within a particular experimental context. Hockey argues that subjects are required to recall associations between items in the paired-associate tests and that the results suggest that high arousal leads to better episodic memory, because of the stronger ordering and literal storage of information.

So far we have seen that although Walker's action-decrement theory can account for the interaction between arousal and retention interval, the results obtained are not always the ones predicted by the theory. As an alternative to Walker's consolidation hypothesis, a plausible explanation for high arousal being associated with better long term memory has been offered by Craik and Blankstein (1975). They suggest that an arresting, emotional or interesting stimulus will receive greater attention, and in view of Waugh and Norman's (1965) findings that learning is positively related to the amount of attention or processing an item receives, it is not surprising that high arousal interest items are forgotten less rapidly than items receiving less attention. This hypothesis will be considered again in the discussion of experiments using a free recall paradigm.

1.3 Experiments Utilizing the Free recall Paradigm.

In a similar vein to the paired-associate studies, a number of studies have investigated the effects of item arousal on retention, using the free recall paradigm. Schonpflug and Beike (1964) presented twelve words of either high or low emotionality with either intentional or incidental learning instructions. Analysis of the free recall scores showed that in intentional learning conditions, high emotional words were better recalled than neutral words. A similar pattern also emerged for the incidental learning conditions, but overall performance here was markedly lower than with intentional instructions. GSR's measured during learning confirmed the assumption that emotional words were more arousing since they produced higher skin conductance levels than neutral words. Maltzman, Kantor and Langdon (1966) also tested free recall of a list, either immediately after presentation or thirty minutes later, for high arousal or low arousal words. They showed that high arousal words were recalled considerably better at both retention intervals. Additionally, unlike the results with paired-associate recall, no interaction between retention interval and item type was found. A number of similar studies by Kaplan and Kaplan (1968), Kaplan, Kaplan and Sampson (1968) and by Sampson (1969), each of which manipulated item arousal, confirmed that free recall for high arousal items is better than for low arousal items.

More recently researchers have chosen to manipulate arousal independently of the to-be-recalled items, inorder to overcome the problem of some items being more arousing for one subject, but not for others. In an early study of Schonpflug and Schaffer (1962), subjects were presented lists of fifteen nonsense syllables to learn in the presence of a continous tone which varied in intensity for different groups, through the range 45 to 95 dB. Trials to learn were used to measure performance. This was found to be highest at 55 dB and at 95 dB and worst at 45 dB, with performance declining between 55 and 85 dB. Haveman and Farley used two levels of white noise (40 and 79 dB) in a task where subjects were required to learn ten-item lists of nonsense syllables. Recall was found to be equivalent in the two noise conditions on an immediate test, but improved for the loud noise group in a test carried out twenty four hours after presentation. A significant interaction between noise level and retention interval was also obtained.

Some free recall studies thus show that item arousal and noise induced arousal do not necessarily impair immediate recall. This of course contradicts the findings obtained by Kleinsmith and Kaplan (1963) using paired-associate learning. The only free recall study supporting the paired-associate finding is that of Haveman and Farley (1969). As pointed out above, Haveman and Farley also observed an interaction between noise level and retention interval, but even in this study loud noise did not impair performance on the immediate test although it did improve performance on the delayed test. What seems clear therefore, is that the evidence with regard to the effects of arousal on short term memory is not as straightforward as it first appeared, but is actually rather ambigous. A number of studies have shown either no effect of arousal on immediate memory or an improvement, depending on the memory task used. However, this is not the case with the delayed recall data where high arousal has generally been shown to improve recall. This disassociation of the effects of arousal on short and long term memory thus seriously undermines the usefulness of Walker's action decrement theory, since it can no longer explain the results observed. This point has been made by several reviewers and in particular by M. Eysenck (1976, 1977) and by Hockey (1979) who in addition to the criticisms outlined above have raised several other difficulties with Walker's theory. For example Hockey observes that: "A number of studies find no effect on long term recall of arousal inducing treatments applied after presentation of material to be learned, e.g. Berlyne et al., (1969). If as Walker (1958) argues, the effect of arousal on the consolidation process is non-specific the increase in stimulation level after presentation should result in the same kind of effect as that found with high arousal during learning".

Eysenck points out: "An implication of Walker's hypothesis is that memory traces differ from one another quantitatively, i.e. high arousal makes traces stronger than they would otherwise have been. The findings of Hamilton et al., (1972) however indicate that high arousal may affect qualitatively the resultant memory trace". Hockey further adds "since the effects of noise depend so critically on whether order information between successive pairs of items is relevant or not, the idea that it impairs short term recall through its consolidation effect must be rejected. Instead these data must imply that noise increased the use made of sequential or positional information present in a task".

Semantic processing in high arousal conditions.

Easterbrook (1959) proposed that an increase in arousal level restricts the range of cues that a subject has available in performing a task. During low levels of arousal, selection in the utilization of cues is also low and irrelevant cues may be accepted uncritically, but when arousal is very high some relevant cues may no longer be available resulting in poorer task performance. Similarly Hockey (1970) and Broadbent (1971) have suggested that an increase in arousal level directs attention towards high priority (i.e. dominant) task components and away from low priority (i.e. non-dominant) ones. The earliest study to investigate whether noise affected organizational tendencies was carried out by Hormann and Osterkamp (1966). These researchers measured the amount of clustering by category in the recall protocols and used this as an indicator of semantic organization. 95 dB white noise was presented during recall of words from six categories to groups of subjects showing high or low interfering scores on a Stroop colour test. Semantic organization, as indicated by the size of the clusters, was found to be reduced in the high interfering group in noise, the reverse trend being found in the low interference group. Unfortunately no statistical test was carried out to see if this effect was significant or not.

Schwartz (1973) noting the study by Hormann and Osterkamp (1966) and bearing in mind the findings of Hamilton et al., (1972) hypothesised that since arousal could impair memory by reducing semantic clustering or improve it by facilitating order recall, the effects of arousal would be a function of the interaction of a number of factors including the nature of the material to be remembered and the efficiency of the organization strategy used. On the basis of this he developed a model which proposed that arousal facilitates memory when recall is based on the physical characteristics of the stimuli but hinders it when recall is based on the semantic aspects of the stimuli. More recently a levels of processing view (Craik and Lockhart, 1972) has also been used to point out this distinction. Here it is assumed that white noise induces lower level encoding of a limited number of attributes and that fewer deeper features of the information presented are encoded. Returning to Schwartz, in an experiment carried out to test his model, Schwartz (1974) presented subjects with four types of stimulus material: normal sentences, anagram strings, anomalous strings and random words. White noise or silence accompanied the presentation of the material and subjects were required to recall as many items as they could immediately after completion of the list. The results showed a significant noise by sentence type interaction in which normal sentences were found to be the worst affected by noise. Thus it was suggested that noise impaired semantic processing as the normal sentences presumably contained the most semantic features. In the second experiment Schwartz manipulated arousal again by using white noise but this time required subjects to learn either unrelated words, phonemically related words or semantically related words. Free recall was tested either immediately or 2 minutes later; results showed that at both retention intervals there was a highly significant interaction between noise level and type of material with the high noise condition improving recall of phonemically related lists and impairing recall of semantically related lists.

Similarly, Daee and Wilding (1977) showed that white noise reduced the number of items remembered in a free recall task, but that noise had a non-monotonic effect on category clustering and recall in the correct sequence. Three noise conditions were compared: quiet (approximately 65 dBC), 75 dBC and 85 dBC and it was shown that category clustering was lowest and recall in the correct sequence highest at 75 dBC. In explanation,Daee and Wilding propose that increased noise or arousal level prolongs the duration of traces: "At an intermediate level of noise, traces are of optimum duration to establish a connection with the trace of the next item when it arrives, without being connected to traces of later items..... At still higher levels of noise traces last longer, and more interconnections develop and therefore compete with each other", (p. 346).

In a study by Smith (1980), noise was presented at both learning and recall. Analysis of the free recall scores again showed reduced category clustering after exposure to the 85 dB, compared to the 55 dB conditions. On the basis of similar results obtained by manipulating test anxiety, Mueller (1976, 1977 and

1978), Mueller and Overcast (1976) and Mueller, Carlmusto and Marler (1977 and 1978) have suggested that high anxiety induces maintenance rather than elaboration processing. As pointed out earlier, this distinction arose out of Craik and Lockhart's (1972) proposal that rehearsal may either elaborate the trace of incoming material by incorporating more features of the items or that rehearsal may repeat processing of the components already analysed and therefore maintain analysis at a given level. Wilding and Mohindra (1982, paper submitted for publication) in extending this hypothesis to noise point out: "Maintenance processing does not imply lack of semantic processing, since words may be processed semantically but few features or associations or relations between the items encoded, because rote repetition of the list is the strategy adopted to deal with the memory task. The absence of category clustering in free recall could therefore be due to either lack of semantic processing or to lack of elaborative processing which organizes the words into category groups". Clearly it is necessary to test the efficiency of semantic processing under the different conditions more directly, particularly because in the above experiments of Hormann and Osterkamp (1966), Schwartz (1974), Daee and Wilding (1977) and Smith (1980) subjects had a choice of strategy, therefore absence of semantic effects does not imply that they could not process semantically if required to do so.

There have also been indications from the time of day literature that subjects show a preference for different types of processing as arousal (as indicated by increases in body temperature) increases over the day. Folkard and Monk (1979, Experiment 3) showed that in an immediate free recall test of 15 word lists, tested at either 10.00 hours or 16.00 hours, there was a 0.65 word superiority for the 10.00 hours condition. If however recall was tested after conditions of articulatory suppression (at presentation of items) morning superiority disappeared completely. According to Folkard (1980) this result suggests that: "subjects engage in more spontaneous rehearsal that takes no account of the items' meaning in the morning". In another experiment Folkard (1979, Experiment 2) demonstrated that there was an increase in semantic processing over the day. In this experiment subjects learned a list comprising semantically similar adjectives (for example: huge, large, big etc.) while others learned a control list containing unrelated adjectives. In order to minimize the contribution from short term memory an interpolated task was also required to be carried out between each presentation of the list and its subsequent recall. The detrimental effect of semantic similarity was found to be considerably greater at 19.30 hours than at 10.30 hours, supporting the view that subjects placed greater reliance on semantic processing later in the day. This result contradicts results found with noise, where high levels of arousal seem to impair semantic processing. Post hoc, the difference could be accounted for by the suggestion that time of day is an endogenous variable while noise is more of a distractor. But this is not a complete explanation, therefore some attempts have been made to test the effect of arousal on semantic processing more directly, in order to discover whether it is impaired when it is essential to the task rather than being necessary only if a particular strategy is adopted. Eysenck and Eysenck (1979) directly examined the efficiency of semantic processing for a group of extraverts or introverts, presumably varying in arousal according to H. J. Eysenck's (1967) proposal that introverts have higher cortical arousal than extraverts. The experiment was conducted using a form of the Sternberg (1966) memory scanning task in which subjects were presented with a set of words (the memory set) followed by a single word (the target word) and asked to say whether the target was present or not in the memory set. Subjects performed in either a physical match condition or a semantic match condition (judging whether the target was a member of the categories presented in the memory set). The results showed that there was no difference between introverts and extraverts in scanning for physical features, but that introverts were slower than extraverts in scanning for semantic features of category membership, due to a rapid increase in decision time with an increase in size of memory set. Dual task conditions, where scanning had to be performed on the basis of either a physical or a semantic match also showed that introverts were slower than extraverts and supported the hypothesis that high arousal reduced the extent of parallel or shared processing.

In addition to the manipulation of subject arousal, Eysenck and Eysenck included white noise in some conditions. 85 dB intensity white noise was presented intermittently while subjects performed the search task. Results with noise however failed to have any significant effect on response latency. Wilding and Mohindra (1982, paper presented for publication) also examined the effects of noise in a memory scanning task. Here subjects responded positivelyto the target item if it was identical to any item in the memory set (physical match condition) or if was synonymous with any item in the memory set (semantic match condition). No effects of noise over the three intensities used (65 dbC, 75 dBC or 85 dBC) were obtained, supporting the notion that reduced category clustering in noise must be due to an optional strategy of reduced elaboration in processing rather than a reduction in access to the semantic code.

More recently this question has been explored further in experiments investigating the effects of noise on clustering in conditions where subjects carry out different orienting tasks. In this manner the type of processing an item receives can be controlled. An orienting task which involves rating an item along the dimension of pleasant - unpleasant is generally thought to invoke semantic encoding. Walsh and Jenkins (1973) found that rating items along such a dimension enhanced performance in a free recall task relative to two non-semantic orienting tasks. In the latter tasks subjects were required to estimate the number of syllables contained in each word or to look for words which contained an 'e' or a 'g' in its spelling. With regard to the effects of noise the following predictions can be made. Should noise continue to reduce category clustering when semantic processing is induced by use of an orienting task, we can conclude either that the orienting task has failed to be effective or, more plausibly, that elaboration in the sense previously discussed does not occur in noise. If however, the reduction in category clustering in noise vanishes or is reduced, then we can conclude that noise acts principally by inducing a preference for maintenance processing which can be countered by instructions.

In conditions of 65, 75 and 85 dBC white noise, Wilding, Mohindra and Breen-Lewis (1982) used either a semantic orienting task by asking to rate the pleasantness of items, or no orienting conditions, inorder to control level of processing. In addition possible breadth of coding was manipulated by using two types of lists: those containing associated items and those containing non-associated items. Free recall of the non-associated list, without the orienting tasks, showed the usual increase in recall by sequence in noise; while the total number of words recalled in the three noise conditions was not significantly different. Introduction of the orienting task however, caused a decline in recall in noise, suggesting disruption of the preferred maintenance rehearsal strategy. For the associated lists without orienting, some decline in total recall and clustering of associated items was found in noise; with semantic orienting in noise, a marked increase in both these measures occurred. Wilding et al. concluded that subjects, when forced to process words semantically, make better use of relevant semantic features if exposed to loud noise. This suggests that the preference for maintenance rehearsal in noise is not irreversible, but a spontaneous strategy adopted by subjects inorder to maximize perceived outcomes. A subsequent experiment by Wilding et al. examined the effects of a physical orienting task (judging whether words contained certain sounds). Here it was anticipated that such judgements would be compatible with a maintenance rehearsal strategy in noise and that therefore, some improvement under noise would occur for the non-associated list. As predicted, the results showed that the physical orienting task improved performance on the non-assocaiated list and impaired it on the associated list. Thus the postulated increase in maintenance rehearsal appeared to benefit the non-associated items.

Strategy changes in noise.

The results of the experiments by Wilding et al. (1982) substantiate the position that semantic processing is not necessarily impaired in noise, but that maintenance rehearsal accompanied by processing of physical attributes tends to be a spontaneously adopted strategy in noise, unless instructions induce an alternative strategy, in which case noise reinforces use of the alternative strategy. Nevertheless the decision about which factors affect the strategy adopted by a subject in any given circumstance appears to be a particularly difficult one. Wilding (1980) proposes that the difficulty in identifying whether passive or strategic changes underlie changes in performance can perhaps be clarified by making the distinction by analogy with hardware and software changes in computing terminology. The effects of noise on performance can then be considered, on the one hand to reflect strategic or software changes, probably associated with some alteration in the allocation of processing resources to the task being performed, or, on the other hand, structural or hardware changes, for example, a reduction in memory capacity or an increase in the speed of mental operations. Wilding also pointed out that the principal criterion for determining whether a particular performance change is structural or strategic, is the generality of the effect on performance. But, as was noted earlier, at this stage there is no agreement on what constitutes a general effect either between arousers, or with use of the same arouser applied under different memory paradigms. Therefore, it remains unclear whether the effects of noise on performance will ultimately be explained in terms of hardware or software changes, or some combination of the two.

1.4. Experiments Utilizing the Serial Order Recall Paradigm.

Though the results are far from being completely consistent, the evidence for a relationship between noise and order information in the paired-associate studies (Hockey and Hamilton, 1970; Hamilton, Hockey and Quinn, 1972) and in the free recall studies (Daee and Wilding, 1977; Wilding, Mohindra and Breen-Lewis, 1982) has suggested that high intensity white noise improves serial order recall. Direct measures of serial order recall support this conclusion (Wilding and Mohindra, 1980; Millar, 1979). However, there have been some experiments reported where no effect of noise was found on ordered recall (Miller, 1957; Murray, 1965; Sloboda and Smith, 1968; Haveman and Farley, 1969 and Davies and Jones, 1975) or an impairment was shown (Wilkinson, 1975; Salame and Wittersheim, 1978). This discrepancy led Wilding and Mohindra (1980) to conclude: "It is unclear what features of the task are important in determining the direction of the noise effects". In addition they point out that few direct measures have been made of the effect of stressors other than noise on recall of order. Data from tasks requiring ordered recall, such as digit span and serial recall are confusing and do not support the view that stressors in general improve short term recall of order. For example, Eysenck (1977), in reviewing the evidence for the effects of anxiety on digit span quotes a number of studies which suggest that stress and high levels of state anxiety have detrimental effects on digit span (e.g. Dunn, 1968; Griffiths, 1958; Hodges, 1968; Moldawskyand Moldawsky, 1952; Pyke and

Agnew, 1963), whereas trait anxiety has negligible effects. Studies by Blake (1967) and by Baddeley, Hatter, Scott and Snashall (1970) found worse serial order recall later in the day when arousal is higher. This was further supported by Jones, Gale and Smallbone's (1979) finding that memory performance was best in the morning when EEG arousal was lowest. However, all these results contradict Folkard's (1976) finding that running memory is superior later in the day. Folkard (1976) also showed that arousal induced by muscle tension reduced serial recall. In addition, Parker, Alkana, Birnbaum, Hartley and Noble (1975); Rosen and Lee (1976); Weingartner and Faillace (1971) all found that alcohol reduced digit span. Davies and Jones (1975) and Fowler and Wilding (1979) showed that whereas incentives aided recall of order and recall of spatial position, noise aided recall of order but impaired recall of spatial position. Dornic (1974) showed that addition of a secondary task, higher information load and alcohol all reduced recall of item information, but not of order information and also showed that preventing subjects from verbalizing items internally affected recall of order information but not of item information.

Commenting on the incoherence of the above findings, Wilding and Mohindra (1980) conclude: "It is best to treat noise as a distinct type of stimulus and attempt no predictions based on results obtained with other types of arousing stimulation".

With regard to noise, several explanations have been put forward in an attempt to explain its effects on serial learning.

As discussed previously, explanations in terms of arousal are not very helpful, since these do not precisely state the mechanisms that are involved. Hockey and Hamilton (1970) and Hamilton et al. (1972) argue that attentional capacity is increased in high arousal conditions, which leads to storage of more information about the presentation order of items. Dornic (1975) suggests that noise may have similar effects to that of increased task difficulty, resulting in subjects making more use of a 'lower' storage mechanism which carries more order information. This is distinguished from a 'higher' storage mechanism which involves identification of stimuli according to their names or meanings, rather than according to their physical features. Daee and Wilding (1977) suggest that noise prolongs stimulus traces thus facilitating the development of sequential associations between items. One possible way in which this could occur would be by noise slowing the rate of rehearsal and thus prolonging the stimulus trace, but this will be discussed in greater detail at a later stage.

Another explanation is that of Hamilton, Hockey and Rejman (1977) where it is proposed that in states of high arousal faster throughput of information occurs, giving increased efficiency on tasks requiring rapid handling of continous input, but poorer memory registration. This conclusion was derived from the results of a running memory experiment in which 30 random consonants were presented at different rates in different conditions and subjects were asked to recall the last item preceding the one they were interrupted on. Their results showed that for each of the four rates of presentation used, recall in noise was better for recently presented items, but that these items showed a faster fade off in memory.

Following Dornic's (1975) finding that preventing subjects from verbalizing items internally affected recall of order information, Folkard (1976) argued that an important factor in experiments on short term memory may be that subvocal activity is reduced under high levels of arousal. Baddeley and Hitch (1974) have proposed a model of 'working memory' memory which incorporates two processes: a central executive system and an articulatory loop. The latter is suggested to be used for subvocal rehearsal of incoming material, whereas the central executive is assumed to be responsible for information processing, decision taking and storage. Folkard hypothesised that high arousal would impair efficient utilization of the articulatory loop, but would have little effect on the central executive. In an experiment comparing digit span in conditions of induced muscle tension or no muscle tension, Folkard (1976) found that arousal had a detrimental effect on performance in 'free' conditions in which subjects were allowed to rehearse if they wished, but were not instructed to do so. In suppression conditions, where subvocal rehearsal was minimized, there was no effect of arousal on performance, although the overall level of performance declined in comparison to the free condition. A third condition where subjects were required to articulate the digits out aloud, failed to counteract the effects of muscle tension, as presumably it should, if Folkard's suggestion was correct. Wilding and

Mohindra (1980) point out that as articulation conditions produced slightly worse results than subvocal rehearsal and muscle tension, articulation is not just making overt the activity of the articulatory loop but perhaps also interfering with other processes. Murray (1965, 1966, 1968) for example, had shown an improvement in serial recall when items were required to be articulated and therefore Wilding and Mohindra conclude "It may be unwise to base any conclusions on the Folkard result".

Along similar lines to those of Folkard, Poulton (1976, 1977) has suggested that white noise masks auditory feedback and inner speech. Hence impairment in short term memory performance is seen by Poulton as resulting from a masking of the subvocal rehearsal, normally required to maintain information in short term store. In addition Poulton (1979) proposes that the encoding of inner speech or rehearsal could be either articulatory or acoustic and that the interference produced by the masking effect of noise is likely to disrupt the acoustic form of rehearsal or inner speech and hence force the subject to resort to the articulatory form of rehearsal. Broadbent (1978), however concludes that " visual stimuli are not stored as an acoustic representation but as a pattern of articulatory commands". As such, there is no reason why noise should disrupt rehearsal.

Recently, Millar (1979) has provided evidence against both the proposals put forward by Poulton, i.e. that noise masks internal speech, and therefore disrupts memory and secondly that should noise mask the auditory form of inner speech, prevention of articulatory rehearsal would result in a considerable impairment in memory. Millar (1979) examined the effects of both suppression and noise on the recall of a list of eight consonants on the assumption that if noise masks inner speech, it will have the same effects as those of articulatory suppression. The results showed that 92 dBA, compared to 75 dBA white noise, had a detrimental effect on the total number of items recalled correctly when subjects rehearsed normally. However when subjects were required to count from 1 - 7 while consonants were being presented, no differences in performance were observed between the two noise groups. On reflection Millar noted that the above result actually supports the masking hypothesis, but if measures of serial order recall rather than total recall were considered, a completely different picture emerged. Recall of serial order recall in the suppression condition remained stable in noise, relative to quiet conditions where performance declined over test days, while in rehearsal conditions the loss of serial order information in noise occurred to a lesser extent on the second day, compared to the first day, when no reliable differences were found. Therefore serial order recall performance was better preserved in loud noise regardless of whether rehearsal was prevented or not. As pointed out by Hartley (1981), this is contrary to what would be expected if noise had masked the auditory encoding of items when articulatory encoding was suppressed. Further findings of Millar, such as the reduction in noise of the number of commission errors (recall of consonants not presented on the trial in question) and a reduction in the number of acoustic confusions all indicate that the masking hypothesis is not the most plausible explanation of the results. Millar in fact concluded that such performance may be consistent with an interpretation suggesting an attentional influence of noise. Further evidence against the masking hypothesis has been reported in a series of experiments by Wilding and Mohindra (1980). They also investigated the effect of articulatory suppression and white noise on the serial recall of visually presented sequences of acoustically confusable and non-confusable consonants. Noise and suppression were shown to have different effects. Whereas suppression impaired performance on all lists, the non-confusable ones more than the confusable, noise had the opposite effect of improving performance on the acoustically similar stimuli. Wilding and Mohindra suggest that this result is compatible with the view that the articulatory loop, in Baddeley and Hitch's working memory model, is pre-empted in suppression conditions, but that noise does not just increase use of the articulatory loop, as this would result in an increase in the number of confusions among acoustically similar items, but somehow improves the quality of the information in the loop.

Both these studies thus clearly refute the hypothesis that noise and suppression act in the same way. Instead as pointed out by Wilding and Mohindra, the results suggest that noise may act by increasing the strength of inner speech, a possibility also suggested by Poulton (1977). In order to test this hypothesis, Wilding and Mohindra carried out a further experiment to see whether articulating aloud had the same effects as noise. Results of this experiment showed that overt articulation improved recall performance, when lists were presented at a fast rate ($\frac{1}{2}$ s per item), but depressed it when they were presented at a slower rate of 2 s per item. Also some improvement with noise was shown in articulation conditions, but the effects of noise only reached significance in the non-articulation conditions. Given this somewhat unsatisfactory position two further experiments were carried out to clarify the position with regard to the interaction of noise, articulation and presentation rate. From these it was concluded that articulation aids performance at a fast rate of presentation, and that in these conditions its effects were in the same direction as those of noise, but that articulation did not improve performance at slow rates of presentation, while noise did. So far then the position can be summarised by saying that the effects of articulation and noise somewhat resemble each other, whereas those of suppression and noise do not.

1.5. Conclusions.

From the previous sections it will have been observed that different stressors produce sometimes similar and sometimes different effects upon memory performance, depending on a number of factors. The proposal that the inverted U relationship (Yerkes and Dodson, 1908) could explain the effects of arousal manipulation was rejected on the grounds that it represented a descriptive relationship between two variables without explaining the processes which produced that relationship.

The experimental evidence suggests a more complex organization with many of the current theories containing some element of truth. The major problem seems to be that of explaining the relationship between these hypothesised systems and the complex relationship between arousal and recall as observed in the different experimental paradigms.

Even if it is assumed that various memory tasks induce utilization of different processing strategies, a comparison of the effects of different stressors revealed a number of discrepancies in the results obtained. With reference to the paired associate learning studies, there is the generally observed interaction of relatively better delayed recall for higher levels of arousal and poor immediate recall. In free recall however, this effect is not replicated, instead free recall appears to depend on a number of other factors. Amongst these are the types of lists used and the method of stress manipulation. For the latter of these factors it was observed that whereas the results from the noise, anxiety and possibly introversion literature appear to support the levels of processing model, with high arousal being associated with physical, lower level type maintenance processing and low arousal with semantic - high elaboration type processing, the results from the time of day studies led us to draw the opposite conclusions. In general, however, no reliable effects of any stressor were found on total correct recall and only when measures of sequencing and

and category clustering are considered do the subtle effects become apparent.

There still remains the problem of long term recall. This in terms of current memory models is assumed to rely more on semantic information. As it is, most of the results which show an improvement from long term memory are derived from use of the paired associate learning paradigm and do not contain stimulus items which can be remembered semantically. Some other process is thus implicated.

The only result which does not have to rely on a paradigm specific explanation is the finding that white noise appears to increase subjects reliance on order recall. It will be remembered that Hamilton et al. (1972) demonstrated that if recall for paired associates was tested using the same order of pairs, as used at presentation, then noise produced a significant improvement in performance over the no noise condition. Further in a free recall paradigm Daee and Wilding (1977) and Wilding et al. (1982) have shown that recall in the correct sequence increases with noise level. Daee and Wilding (1977) actually obtained higher sequence recall in 75 dBC conditions, but their lists contained some items which could be recalled in categories and some which were random. What effect this would have had on sequence recall is unknown. Finally, using serial order recall Dornic (1973), Hockey, Hamilton and Rejman (1977), Millar (1979) and Wilding and Mohindra (1980) have all shown an improvement in recall in the correct order with items presented under loud noise. The generality of this finding forces us to consider what it is about recalling items, in order, in noise, which contributes to this effect. This question forms the basis of the next chapter.

CHAPTER 2

PHONOLOGICAL CODING AND THE RECALL OF ORDER INFORMATION IN SHORT TERM MEMORY

Various researchers have attempted to examine the role of inner speech in conditions where short term recall of serial information presented visually in white noise is required (Murray, 1965, 1967; Millar, 1979; Wilding and Mohindra, 1980). The interest in inner speech stems from Sperling's (1960) observation that when a person is required to read a group of consonant letters and later recall them, subjects seemed to be using an auditory or phonological code, mumbling, whispering and mouthing the names of the letters even though the presentation was visual.

As discussed in Chapter 1, recently Poulton (1976, 1977) has suggested that the effects of noise on short term memory can be explained in terms of masking of verbal rehearsal or subvocalization, which is necessary to extend the duration of items in store. Folkard (1976) has suggested that muscle tension and later times of day reduce the incidence of covert speech or subvocal activity. These and other similar propositions suggest that there is a need to consider the phenomenon of inner speech and in particular the role it plays in helping to maintain information in short term memory.

In order to answer this question I shall briefly trace the development of research involved in outlining the processes which transfer visual input into a speech motor output. These processes are also involved in the activity of reading. Discussion of the reading literature will however be deferredto Chapter 6.

The research of Conrad (1964) was the first in investigating relationships between memory errors under visual presentation and the phonological similarity of the letters being remembered. Conrad demonstrated that confusion among letters missed in a visual memory experiment were letter by letter the same confusions that occured in an experiment on listening to individual letter names presented for identification against a background of noise. This was interpreted as evidence that the subjects in the visual experiment recoded the input into a phonological speech based format for retention at some level of the analysis. Conrad and Hull (1964) went on to show that sequences of phonologically similar letters such as B D G T P C were less likely to be correctly recalled than a string of phonologically dissimilar letters such as H M K J R Z. A number of other studies have also shown that when verbal items-letters or consonants, are visually presented for immediate recall, the material is coded in phonological form (Baddeley, 1968; Hintzman, 1967; Murray, 1966; Wickelgren, 1965).

Crowder (1978) has suggested that there are infact two related phenomenon demonstrated by Conrad. He calls these:

(a) The Confusion Effect - this refers to a situation of similar substitutions being made in listening and in visual memory as reported by Conrad (1964).

(b) The Similarity Decrement Effect - this refers to the to the situation in short term retention where lists contain a high density of phonologically similar items as opposed to phonologically diverse items as exemplified by Conrad and Hull (1964) where the positions of such items are transposed at recall.

Putting this another way it could be said that the confusion effect refers to the situation where extralist intrusions lead to decrement in performance, whereas the similarity decrement effect results from intra-list transpositions.

The reason for separating out two effects was that Crowder hoped to show a dissociation of these effects as a function of some experimental variables. One such example of this is the effect of delay on phonological coding. Conrad (1967) and Estes (1973) have both shown that with a delay of up to 10 seconds prior to recall, there is a decline in the confusion effect i.e. it seems that phonology plays a decreasing role as the time spent before recall in some type of distractor task increases. However experiments on the similarity decrement effect have not produced the same results as far as disappearance of phonological coding with time is concerned. For example, in an experiment reported by Baddeley (1966), phonologically homogenous and phonologically heterogenous lists each containing several words had to be retained. Following presentation of the words a stream of digits had to be copied prior to recall. The results failed to show any difference in the rate of forgetting over intervals of up to ten seconds for the two types of lists and although there was a similarity decrement effect, its size did not change as a function of the length of the delay. Posner and Konick (1966) examined the similarity decrement effect using the Brown-Peterson paradigm. Here performance was again compared on items of high or low phonological similarity, after intervals filled with tasks whose cognitive complexity was varied. The size of the similarity decrement effect increased as a function of the retention interval, but was found to be independent of the complexity of the interfering task. Finally, Liberman, Shankweiler, Fowler and Fisher (1977) tested the memory performance of a group of first grade children, grouped according to their reading ability on lists of either high or low phonological similarity. The tests, which were carried out either immediately after list presentation, or after an unfilled delay of fifteen seconds showed that an increase in the similarity decrement effect took place for the good readers over the delayed interval, but that no change occurred for the immediate and poor readers. The results of all these experiments led Crowder to suggest that the inconsistencies between the Confusion and the Similarity decrement effects, as indices of phonological coding across lengthening delay intervals, might be rationalized in terms of a rehearsal mechanism. The two latter studies i. e. those of Posner and Konick, and that of Liberman et al., both of which showed an increase in similarity decrement at longer delays, are also those which allowed the most opportunity for rehearsal during those delays. Crowder thus considers that rehearsal, as an inherently phonological activity, could restore an otherwise fading phonological code. This evidence further supports the conclusion that phonological coding will be evident to the extent that subjects have had a recent opportunity for rehearsal, and not that phonological coding is an inherent part of the system for encoding visual information. Estes (1973, Experiment 2) has further shown that where subjects were discouraged from using phonological codes, by speeding up the rate of presentation of items from 400 ms per item to 200 ms per item, the confusion effect still occurred, but only if rehearsal was introduced within 1s of the original presentation, clearly tying the confusion effect to the opportunity for rehearsal. In this experiment rehearsal periods were inserted either early, midway or late in the digit shadowing task that accompanied the retention interval, these periods being intended to determine whether rehearsal of the items based on some transitory memory trace could restore the phonological codes abolished by the rapid presentation.

If the peripheral speech motor mechanism is primarily responsible for rehearsal one would expect a decrease in the proportion of phonological errors when subvocalization is inhibited. A number of studies have been conducted where articulatory movements have been suppressed during the processing of visual memory stimuli for later recall. This type of suppression is normally enforced by requiring the subject to repeatedly articulate some irrelevant item such as 'the' or to count aloud repeatedly the numbers 1 to 9. In these conditions, the confusion effect is generally removed (Conrad, 1972; Estes, 1973). Also it has been demonstrated in several studies that with visually presented materials, articulatory suppression eliminates the effect of phonemic similarity (Murray, 1967, 1968; Peterson and Johnson, 1971; Tell, 1972; Wilding and Mohindra, 1980; Richardson, Greaves and Smith, 1981). In addition, Baddeley, Thomson and Buchanan (1975) have shown that performance on an immediate serial recall task is inversely related to word length, across a variety of stimulus materials. In two experiments Baddeley et al. additionally considered the effects of articulatory suppression by requiring the subjects to count aloud repeatedly from 1 to 8. With auditory presentation there was a clear effect of word length which did not interact with the overall decrement in performance caused by articulatory suppression. With visual presentation however, articulatory suppression produced a marked reduction in recall and completely eliminated the effect of word length. This implies that for visual presentation at least, concurrent articulatory suppression removes the contribution to performance of the hypothesised phonologically based articulatory loop.

In summary then, evidence from the suppression studies discussed above strongly favours the concept of articulatory coding. Studies of spontaneously occurring speech myography (EMG) also provide support for phonological involvement in memory, in so far as a high correlation exists between occurrence of subvocal speech and recall. For example Locke and Fehr (1971) found that adult speech EMG amplitude was greater for labial than for non-labial lists of visually presented familiar words, both when recall was written and when it was oral. However the situation is complicated by the occurrence of some conflicting results. Garrity (1977) in a review of the EMG literature highlights two such studies by Glassman (1972) and by Cole and Young (1975). Glassman presented data supporting a peripheral articulatory hypothesis whereas the study by Cole and Young showed that encoding of speech in short term memory does not depend on subvocalization. In both these studies subjects in the experimental group were trained to suppress their laryngeal activity, while control subjects subvocal activity was simply monitored. Glassman presented three word sets of either high or low acoustic similarity and showed that subjects in the experimental group produced a smaller proportion of phonological errors than the control group. In the Cole and Young study all subjects were trained to suppress laryngeal speech but only the experimental group were trained to suppress subvocalization during the experiment. Results of the task, which consisted of monitoring six consonant or vowel syllables indicated a similar pattern of errors during both high and low subvocalization trials.

So far then the evidence suggests that verbal mediation following the occurrence of visually presented stimuli is a naturally adopted strategy, even though in the case of processing phonologically similar items such a strategy results in an impairment in performance. Why then should such a strategy be used ? What purpose, if any, does it serve? Is it necessary that memory for verbal material can only be maintained in this way or is it a supplemental code employed strategically when the capacity of the system is exceeded?

Several lines of evidence suggest that phonological coding may be used as an aid in the retention of order information. For example, Dornic (1975) found that addition of a secondary task, high information load and alcohol all reduced the recall of item information but not of order information. However preventing subjects from verbalizing items internally affected recall of order information but not of item information suggesting that the retention of order information is phonological in nature.

Previously Dornic, Hagdahl and Hanson (1973) had shown that a group of deaf subjects were more likely,in a visual search task, to retain the target set according to categories rather than according to their order, thus confirming Blair's (1957) finding that the deaf are much less dependent on order information than hearing subjects. From this evidence Dornic concludes : "Storing of order information (as specified above) tends to form larger phonological units, chains traces connected together, thus reducing the number of units in a message. In this sense storing of order information does not in fact mean that there is an increase in the amount of information retained but its decrease in about the same way as when forming 'chunks' by recoding a message into less units through learning. That is why as demonstrated in the present experiments, the retention of order information might be an easier process than the retention of only item information and as such is not affected under some 'difficult' conditions while the retention of the latter is".

Further more , Healy (1975) showed that phonological coding in short term memory is not just restricted to memory for order, as opposed to memory for items, but that it is temporal order and not spatial order that is involved. Therefore it has been suggested that the phonological level of representation plays an essentially significant role in the process of reading. For example, Underwood (1978), recognizing the importance of temporal order information, suggested that one very good reason why phonological coding may take place in reading is that it allows the organization of a spatial display into a temporal sequence. Since, not all the information on a page can be processed at the same time because of capacity limitations, phonological coding allows a sequential ordering of the information. This format has the added advantage of having the readers order of input of information being matched to the writer's order of output. Continuing on the theme of the usefulness of phonological coding in the retention of order, Underwood further suggests that phonological coding helps in reading because it provides a memory. According to him:"The integration of words' meanings from sentences is a task requiring the storage of early presented words until later words are available, and phonological coding facilitates this process . Items are stored using the relatively longer lasting traces of auditory memory. Also phonological coding imposes a prosodic structure which allows encoding of features such as intonation and stress which may aid in the disambiguation of the sentence and its encoding in memory ".

Apart from the use of phonological coding in reading by adult readers researchers such as Shankweiler and Liberman (1976) have suggested that a phonological representation serves a useful purpose in the acquisition of reading in young children. Again it is stressed that short term memory is one of the primary linguistic processes essential for comprehension of both written and spoken language. As such, a defect in immediate memory for order information is attributed to poor beginning readers and it is supposed that this problem may be a manifestation of an underlying deficiency in the use of phonological codes (Liberman, Shankweiler, Liberman, Fowler and Fischer, 1977; Mann, Liberman and Shankweiler, 1980; Shankweiler, Liberman, Mark, Fowler and Fischer, 1979). Most recently Katz, Shankweiler and Liberman (1981) have shown that a function of phonetic representation is to aid in the representation of order information, and that poor readers' ordering difficulties are related to their deficient use of phonetic codes. Good and poor readers ability to reconstruct the order of briefly presented stimuli that varied in the extent to which they could be distinctively recoded into a phonetic form was tested. An interaction was found between reading ability and type of stimulus item, with good and poor readers showing no difference with items which were not recodable, but with good readers showing significantly superior performance ordering stimuli that were amenable to phonetic coding. Katz, Shankweiler and Liberman therefore concluded as follows: "since items that are labelled by words would be available to a phonetically based working memory, the results are consistent with earlier indications of good readers' superior ability to make use of phonetic coding in working memory."'.

Overall then three factors seem to emerge. Firstly it seems that use of phonological recoding is linked to the opportunity for rehearsal to occur. Secondly, during rehearsal the form in which the phonological code exists is likely to be articulatory and thirdly, phonological coding helps in the recall of order information. As previously discussed, Baddeley and Hitch (1974) have described a system of working memory which operates on the basis of information being coded phonologically. With this type of model in mind, in the next section I will discuss how such a system may help promote the retention of order information where this information is presented in the presence of noise.

2. 1 Noise and the Recall of Order Information.

It was concluded at the end of the first chapter that the only consistent finding to emerge from studies of the effects of noise and memory performance has been that noise increases recall of information in the original order of presentation. This result was demonstrated in each of the following memory paradigms: Paired associate learning (Hockey and Hamilton, 1970; Hockey, Hamilton and Quinn, 1972) in Free recall (Daee and Wilding, 1977; Wilding, Mohindra and Breen-Lewis, 1982) and in Serial order recall (Hamilton, Hockey and Rejman, 1977; Millar

1979; Wilding and Mohindra, 1980).

In view of the above discussion on the relationship between maintaining information in a phonological form and the recall of order, the experiments reported by Wilding and Mohindra (1980) are particularly illuminating in showing how such a relationship exists in the presence of noise. The first experiment demonstrated that suppressing covert rehearsal, by requiring the subjects to articulate irrelevant items continously during the presentation of the stimulus items eliminated the improvement of order recall under noise. However, requiring overt articulation of the letters improved recall, but only when the letters were presented at a rate of $\frac{1}{2}$s per item and not when presented for 2s per item. Later experiments showed that this difference remained even when subjects were permitted to rehearse aloud in any way they wished, rather than having to read aloud the items as they appeared. Therefore it was suggested that the effects of noise somewhat resembled those of articulation, thus supporting the view that using articulatory representation in noise led to an increase in the recall of order.

The same experiments also showed that noise aided the recall of acoustically similar letters more than that of acoustically dissimilar ones, while articulating aloud tended to have the reverse effect. This may seem somewhat paradoxical since here noise actually reduced phonological similarity whereas articulation generally increases it. If, as was suggested above, noise improved order recall because it promotes use of phonological coding the expectation would be that the phonemic similarity effects should be increased resulting in an overall deterioration in order recall, rather than decreased. This discrepancy can however be reconciled by hypothesising that noise makes traces of items more discriminable or extends the duration of the trace in memory. This suggestion will be discussed later in more detail.

Leaving aside the above paradoxical finding for the moment, the conclusion reached by Wilding and Mohindra regarding their experiments was that the effects of noise could be due to its inducing 'maintenance rehearsal' or subvocal rehearsal of the input in its original order. Increased use of maintenance rehearsal could also explain the decreased semantic organization (Hormann and Osterkamp, 1966; Daee and Wilding, 1977; Smith, Jones and Broadbent, 1981) in free recall of categorizable lists, but the question remains as to when and why such a strategy is adopted. This question forms the main focus of this thesis. In an effort to solve this problem experiments on serial order recall, on free recall and recognition under different test expectations, on rehearsal in noise and on phonological coding in noise were carried out.

CHAPTER 3

NOISE EFFECTS ON SHORT TERM SERIAL ORDER MEMORY

EXPERIMENTS 1 - 4

Several studies have shown a facilitation in recall for lists containing adjacent or nearly adjacent repetitions and a decreasing probability of recall as the lag between presentations of the repeated item increases (Crowder, 1968; Wickelgren, 1965b; Obonai and Tatsuno, 1954). There have been a number of explanations put forward for this phenomenon. It has been suggested that differential attention is given to repeated items as a function of lag (Potts and Shiffrin, 1970). Therefore a facilitation in recall of the adjacent items is an example of the Von Restorff effect (Von Restorff, 1933). On the other hand recall of repeated items may depend on the probability of detecting a repetition and coding this information as a tag attached to the repeated item in memory. Crowder (1968) and Wickelgren (1965) both have suggested the possibility of a detection of repetition processes underlying the lag effect in recall. Lee (1976), however, has shown that the variation in lag does not affect memory for the repeated item but rather affects memory for the repetition event. She further demonstrated (Lee, 1976 b) that facilitation in short term recall is based on a tagging process in which stimuli are categorised in terms of the qualities that distinguish them from

from their context. Therefore immediate recall of critical letters was enhanced when the pair of letters was a repetition or when they were acoustically contrasting, but only when the letters were presented in adjacent positions. Recall of pairs separated by a lag of two intervening letters was not affected by repetition or contrast.

The interesting feature of the effect described above is that it presents a paradigm within which it may be possible to test Daee and Wilding's (1977) hypothesis, that noise prolongs stimulus traces of items. Daee and Wilding argue that, "At intermediate levels of noise traces are of optimal duration to establish a connection with the trace of the next item when it arrives, without being connected to traces of other items........ At still higher levels of noise traces last longer, and more interconnections develop and therefore compete with each other", (p 346). If noise does indeed prolong trace duration, the prediction would be that the repetition effect would extend over more intervening trials and not be restricted to critical items presented in adjacent positions. But this does ignore the effects of traces of the other items which may cancel this out. Nevertheless this paradigm was adopted for the first experiment.

In addition to providing a basis for testing Daee and Wilding's hypothesis, it was also hoped that a partial replication of the result shown by Wilding and Mohindra (1980) could be made. It will be recalled that Wilding and Mohindra found that if memory for sequence was tested by requiring subjects to recall a string of five consonants in their original order of presentation, then noise improved performance for lists containing acoustically confusable items and slightly impaired recall for items in non-confusable lists. Thus acoustic similarity was manipulated again, but for two reasons, once to provide two levels of context as used by Lee, and secondly as a manipulation of the the phonological similarity of the items in the list. Here, in contrast to the lists used by Wilding and Mohindra, items of both high and low similarity could occur in the same list, although in most cases the lists predominantly contained either high or low acoustic similarity items.

3.1 EXPERIMENT 1

Method

Subjects

Twenty subjects took part in the experiment, ten in each noise condition. They were all students or post-graduates from all departments in Bedford College. Each session lasted approximately 30 minutes.

Design and Materials

The overall method was similar to that used by Lee (1976,b). The stimuli used consisted of 48 seven-letter strings presented visually at a rate of two items per second. Some examples which are typical of the type of sequences employed in each experimental condition are shown in Table 1.1. Serial order recall was tested immediately after presentation of the last letter in the string.

Table 1. 1

Representative Examples of Letter Sequences for Each Stimulus Condition. (Critical letters are under-lined).

Critical letter pairs	Context	
	Noncontrasting	Contrasting
	Acoustically dissimilar set	
Repeated		
Lag 0	QLZZJFN	PCNNBGT
Lag 2	JNLQZLH	PBHDVHT
Nonrepeated		
Lag 0	QNFHZJL	CBJLPGV
Lag 2	JQFZHLN	TBQGPZV
	Acoustically similar set	
Repeated		
Lag 0	VPDDGTB	LFBBZJQ
Lag 2	GPDCBDV	ZLCQFCH
Nonrepeated		
Lag 0	PCGVTBD	FLCPNZJ
Lag 2	GPTCDVB	QJTNHPZ

Two sets of letters were used. The distinguishing feature between the two sets being the level of acoustic similarity. The letters F H J L N Q Z were designated as being acoustically dissimilar and the set B C D G P T V was designated as being acoustically similar. For each stimulus string, one letter (for repetition trials) or two letters (for trials with no repeated items) chosen randomly from one of the sets were designated critical items. The remaining five letters were chosen either from the same set as the critical pair (Non-contrasting context) or from the other set (Contrasting context). The critical letters were separated by lags of 0 or 2 intervening letters. In order to keep the number of trials to a minimum, at lag 0 the critical pair was located at serial positions 3 or 4 and at lag 2 the critical pair was located in positions 3 and 6.

In all there were five experimental variables, each with two levels. They were (a) Noise (65 or 85 dBC), with subjects being assigned randomly to either one or the other level, (b) nature of the critical pair (a repetition or two non-repeated items), (c) Lag (0 or 2 intervening letters between presentation of the critical letters), (d) the set from which the critical pair was drawn (acoustically similar or dissimilar), (e) context (non critical letters drawn from either the contrasting or non-contrasting set from the critical pair). Noise was the only between subject variable, the other variables all being within-subject manipulations. Each subject received 3 experimental trials on each of the 16 stimulus conditions.

Apparatus

The letters were presented on the screen of a Commodore 'PET' microcomputer, which was placed on a table approximately 0.5 m in front of the subject. The characters presented on the screen appeared white against a black background and had a height of approximately 4mm and a width of 3mm.

Procedure

Subjects were instructed as follows:

> This is an experiment measuring your ability to remember short sequences of letters. On each trial you will be shown a sequence of 7 letters, one at a time on the screen. The letters will be:
>
> F H J L N Q Z
> or B C D G P T V
>
> in a different order on each trial. The two sets of letters are shown in brown or red, respectively on the keyboard. Your task is to remember the order of the letters.
>
> In any one trial, letters presented can be chosen from either one of the two sets, or from a combination of letters from the two sets. It is also possible that a letter can occur more than once in any trial, and if you do remember a repetition you should record the letter twice in the appropriate positions when you respond.
> Please read out all the letters aloud as they appear on the screen. At the end of the letter sequence a "?" will appear. When you see this please type in the 7 letters in the order they appeared. You must respond with 7 letters even when you are not entirely certain of the accuracy of your response. Then carefully check that the letters you have typed are the ones you intended and press the RETURN key. There is then a short pause before the next trial starts.
>
> There will be 48 trials altogether, divided into two blocks of 24. You will get a one minute rest in between the two blocks. The computer will inform you of the time for rest.
>
> Please wear the headphones throughout the experiment. Before each sequence of letters starts, you will hear a hissing noise through them which will continue until the letter sequence ends.

The instructions were then summarized and a block of 6 practice trials was run. Noise was played two seconds before the onset of the first letter and continued until the presentation of the question mark which indicated that recall was required. The order of presentation of the 48 strings was randomised for each subject by the computer.

The experimenter viewed the displays in parallel with the subject and reviewd the instructions with the subject if he or she failed to keep pace in reading the letters.

Scoring

The results consist of an analysis of the probability of correct response for:

(1) each of the 7 positions in the 16 conditions given to each subject (Acoustic similarity x Repetition x Lag x Context).

(2) both critical letters being recalled in the correct position for each of the above conditions.

(3) at least one critical letter being recalled in the correct position for each of the above conditions.

RESULTS

In each case a split plot ANOVA was carried out on the arc-sin transformation of the probability of correct recall. All effects were tested against their interaction with subjects or, in the case of the effects involving noise, against the corresponding 'subjects within noise' term.

Overall recall

Table 1.2 shows the mean number of letters recalled under all conditions in this experiment. The results of an ANOVA

Table 1.2

Mean overall recall per list (Max. Score 3.0 given three repetitions per condition) for all conditions in Experiment 1.

Noise level	65 dBC		85 dBC	
Context	NC	C	NC	C
Critical letter pairs	Acoustically dissimilar set			
Repeated				
Lag 0	2.143	2.200	1.829	2.086
Lag 2	2.057	1.514	2.000	1.600
Nonrepeated				
Lag 0	2.243	1.657	1.857	1.714
Lag 2	2.400	1.686	2.014	1.314
	Acoustically similar set			
Repeated				
Lag 0	1.500	2.400	1.600	2.271
Lag 2	1.386	1.971	1.614	1.557
Nonrepeated				
Lag 0	1.229	1.914	1.414	1.571
Lag 2	1.157	1.429	1.871	1.571

on the data showed significant main effects due to: nature of the critical pair- repeated vs non repeated ($F=27.95$, d.f. 1, 18, $P < 0.001$); Lag- number of intervening items between repetitions ($F=32.69$, d.f. 1, 18, $P < 0.001$); set from which critical pair was drawn- acoustically similar or dissimilar ($F=30.94$, d.f. 1, 18, $P < 0.001$) and serial position ($F=72.12$, d.f. 6, 108, $P < 0.001$). The directions of these effects were as follows: lists containing repeated items were better recalled than lists containing non repeated items; acoustically dissimilar items were better recalled than acoustically similar items and lists containing items repeated at Lag 0 were better recalled than those containing items repeated at Lag 2. Finally a normal serial position curve was observed. In addition to the above significant main effects several interactions also reached significance. A table summarizing all these interactions is provided in the appendix. For our present purposes I will note only those interactions which involved Noise as a factor. There were two such interactions.

The first was the two-way interaction between Noise and serial position ($F=2.44$, d.f. 6, 108, $P< 0.05$) and can be seen in Figure 1.1. It will be observed that performance in 85 dBC, compared to 65 dBC noise was better in the early serial positions (positions 1 and 2), but worse in later positions (positions 4, 5, 6 and 7). Millar (1979) and Wilding and Mohindra (1980) using 8 and 5 item lists respectively, both showed worse recall of early list positions in noise and better recall of later items. This discrepancy between their results and those obtained here could perhaps be attributed to the different list lengths used. Millar's lists contained 8 items; it is possible that as this exceeds the average memory span, early items are replaced by later items in memory. Wilding and Mohindra however used only 5 item lists, in addition to which the last letter of their list was redundant given that subjects that on each trial the same 5 letters would be presented, albeit in a different order on each trial. In both cases then the recency effect may have been artificially enhanced.

The second interaction to reach significance was that between Noise, letter set from which critical letters were

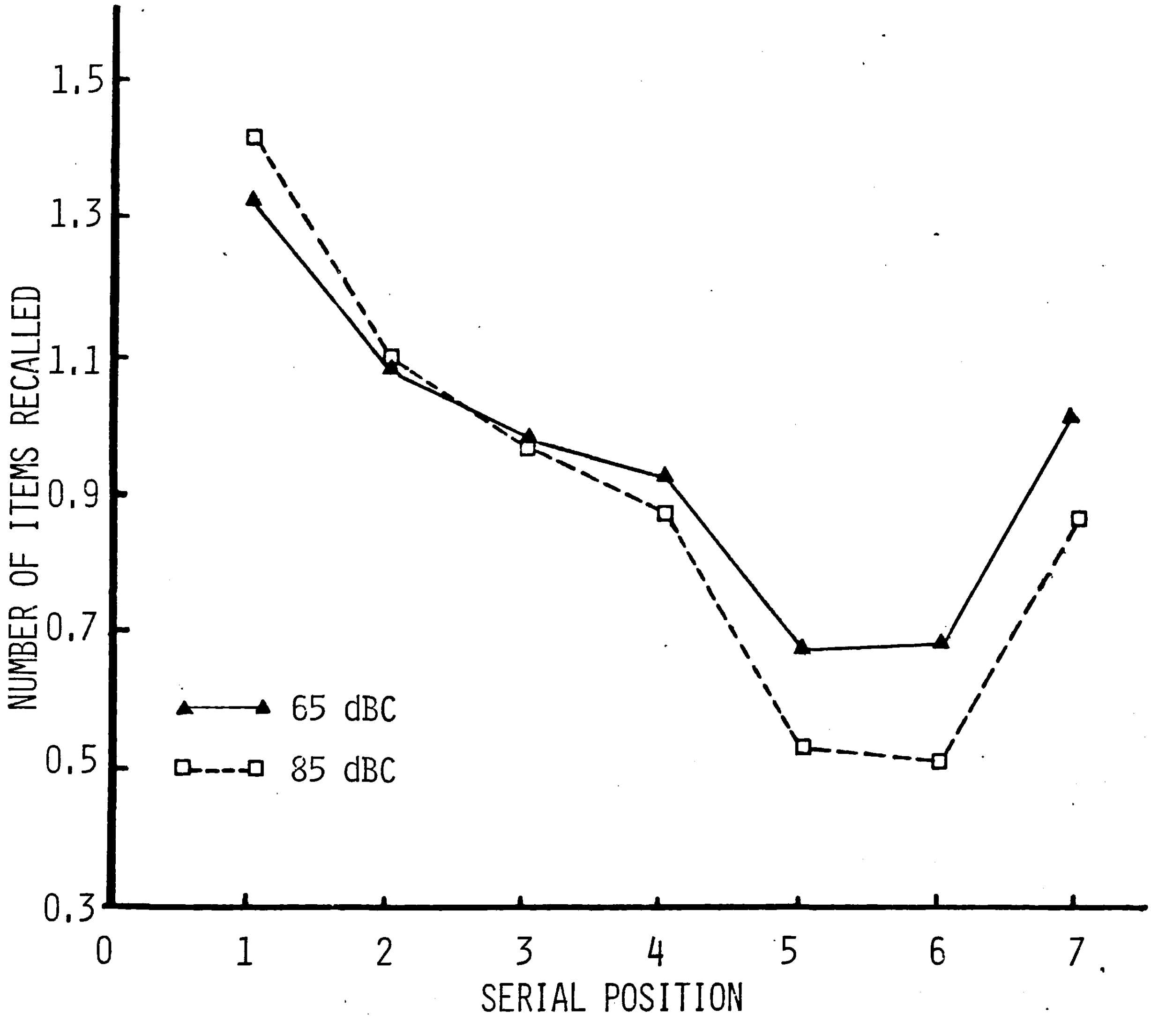

Figure 1.1

Mean number of items recalled overall under 65 and 85 dBC noise at each serial position.

drawn (acoustically similar or dissimilar) and Context (contrasting or non-contrasting). This interaction is shown in Figure 1. 2.

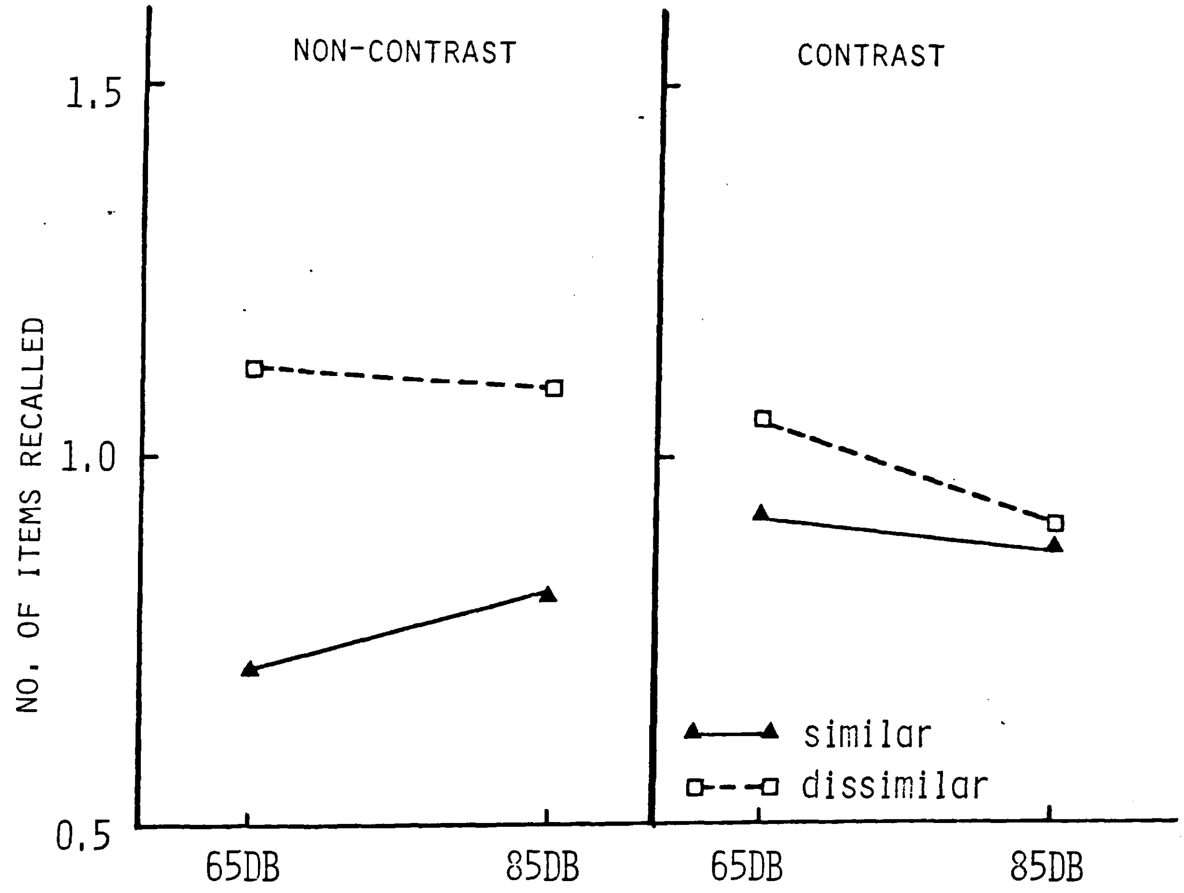

Figure 1. 2

Overall recall for lists with acoustically similar or dissimilar critical items presented in a non-contrasting context or a contrasting context under each level of noise.

This interaction was interpreted as resulting from an improvement in loud noise conditions, for lists comprising critical letters drawn from the acoustically confusable set, presented in a non-contrasting context, i. e. all the letters in this type of lists were acoustically similar letters. The remaining three list types all experienced impairment in recall as a result of being exposed in loud noise. However, lists comprising critical letters drawn from the acoustically dissimilar set, but presented in a contrasting context, i. e. 5 of the 7 letters in this type of list were acoustically similar, showed the smallest impairment in recall during loud noise conditions. This selective improvement confirms the result obtained by Wilding and Mohindra (1980) where a similar improvement was observed in serial order recall of lists containing acoustically confusable letters presented in 85 dBC noise.

An analysis of errors of acoustic confusion (recall of a consonant, acoustically similar to that which was actually presented) showed that fewer acoustic confusions occurred in the 85 dBC, compared to the 65 dBC conditions ($t = 2.46$, d.f. 18, $P < 0.05$). Again this supports Millar's (1979) and Wilding and Mohindra's (1980) result and further emphasizes the notion that noise does not mask rehearsal in a similar manner to its impairment of speech perception. Instead it suggests that perhaps interference from other items is of a lesser magnitude in loud noise and that the benefits of this reduction in interference are greater for lists of acoustically similar letters, i.e. acoustically similar items are somehow more discriminable in noise.

Summarizing the results so far, the overall picture suggests that although repetition of items within a list improves recall for items in that list, this effect does not interact with noise in any clear fashion. However further analysis of the recall of both letters of the critical pair and recall of at least one letter of the critical pair needs to be considered before we can conclude whether noise prolongs stimulus traces, as suggested by Daee and Wilding (1977).

Recall of both letters of a critical pair.

Recall of both letters of a critical pair was analysed separately in order to see whether the experimental variables affected recall of the critical pair as a unit. This type of analysis showed, barring interactions with the additional factor of noise, that the results were virtually identical to those obtained by Lee (1976, b).

The results of an ANOVA on the arc-sin transformations of the probability of recalling both letters of a critical pair showed that recall was improved if the letters stood out from their context, either by being repeated items ($F=43.21$, d.f. 1, 18, $P< 0.001$) or by being drawn from the contrasting set ($F= 4.88$, d.f. 1, 18, $P< 0.05$). However letters drawn from the acoustically similar set were worse recalled than those drawn from the dissimilar set ($F= 37.73$, d.f. 1, 18, $P\leq 0.001$). In addition there were significant effects due to the interaction of Stimulus pair (repeated vs non-repeated) X Lag ($F= 10.65$, d.f. 1, 18, $P\leq 0.01$); Letter set of critical pair X

Context (F= 10.20, d.f. 1, 18, $P < 0.01$); and Letter set of critical pair X Repetition (F= 5.30, d.f. 1, 18, $P < 0.05$). These interactions are illustrated in Figures 1.3, 1.4 and 1.5 respectively.

Two interactions involving noise also reached significance. Firstly, an identical interaction to that observed during the analysis of the overall recall data also reached significance here. This was the interaction between Letter set of critical pair, Context and Noise (F= 17.78, d.f. 1, 18, $P < 0.001$) and is shown in Figure 1.6. This again showed that noise improved recall performance of the acoustically similar pairs when the critical letters were presented in a non-contrasting context. In all other conditions performance in 85 dBC, compared to 65 dBC noise, was impaired. Finally the interaction between Letter set of critical pair, Stimulus pair (repeated vs non-repeated), Lag, Context and Noise was also significant. Breaking this interaction into the components contributed by the repetition trials vs the non-repetition trials, showed that this effect only applied in the latter case. Here it was observed that the acoustically dissimilar critical pairs, presented in a contrasting context, at lag 0 (e.g. CB<u>JL</u>PGV) were recalled better in the 85 as compared to the 65 dBC conditions. However no clear interpretation of this effect was evident apart from the fact that the contrast between the letters of the critical pair and the rest of the items may have enhanced their discrimination.

Figure 1.3.

Recall of both letters of a critical pair (repeated vs non-repeated) at Lag 0 and at Lag 2.

Figure 1.4.

Recall of both letters of a critical pair (acoustically similar or dissimilar) presented in a contrasting or non-contrasting context.

Figure 1.5.

Recall of both letters of a critical pair (acoustically similar or dissimilar) which were either repetitions or non-repeated items.

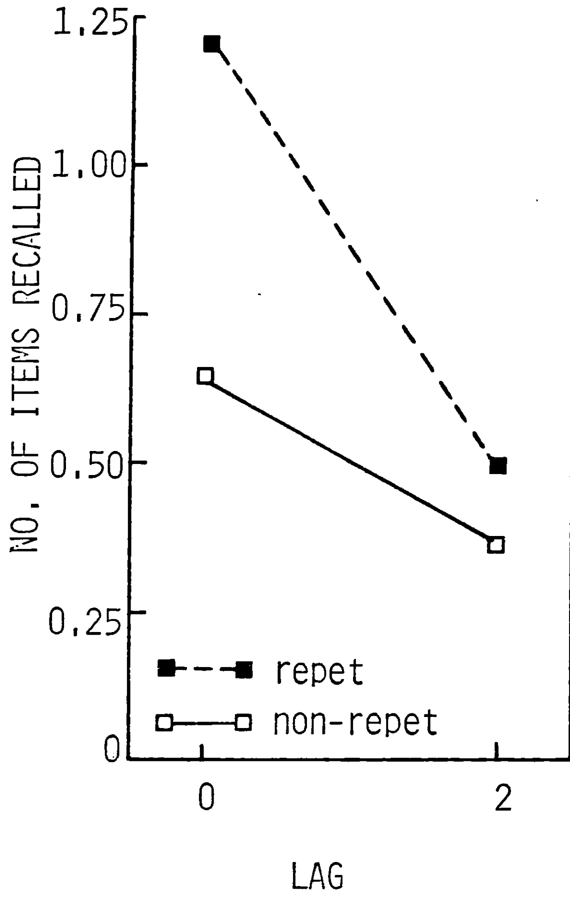

Figure 1.3

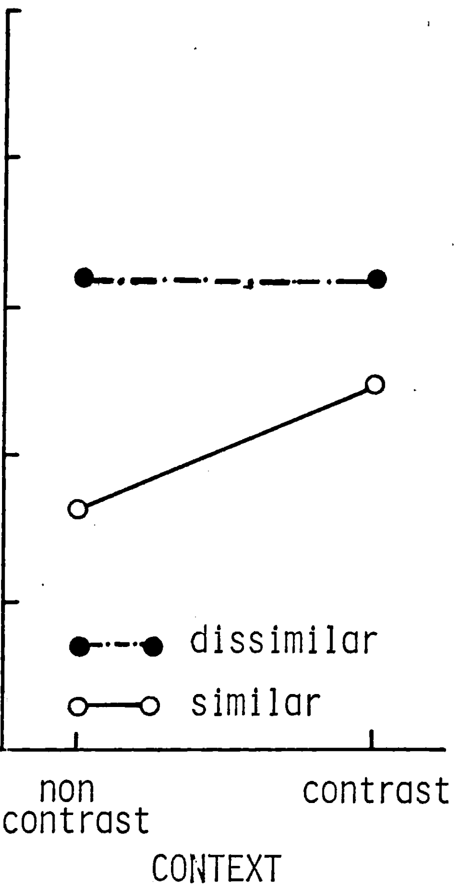

Figure 1.4

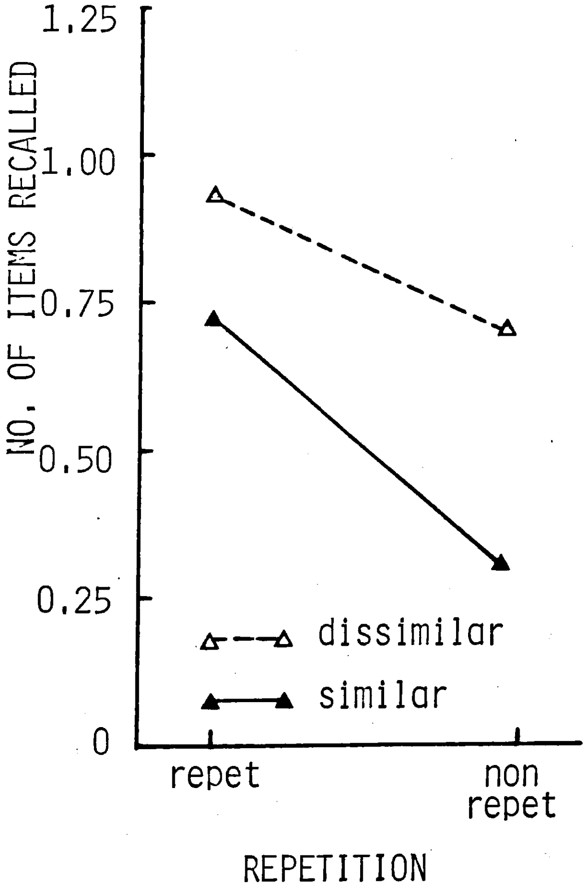

Figure 1.5

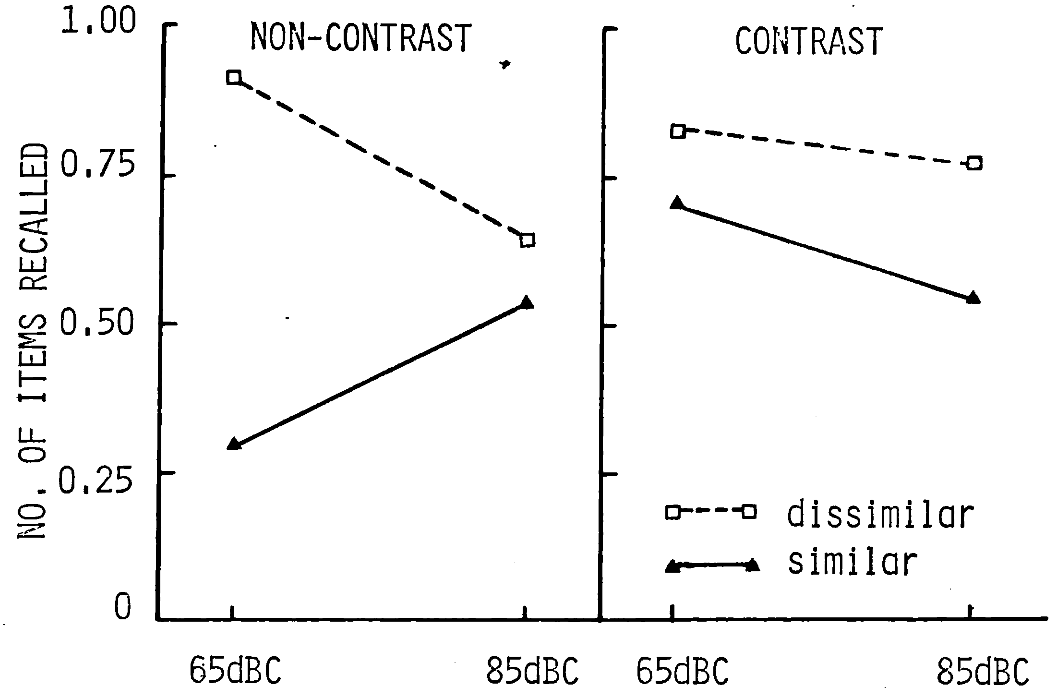

Figure 1.6

Recall of both letters of a critical pair (acoustically similar or dissimilar) presented in a non-contrasting or a contrasting context under each level of noise.

Recall of at least one letter of the critical pair.

Analysing recall of at least one letter of the critical pair showed that almost the identical variables which affected recall of both letters of the critical pair were operative again. This overall trend contradicts the pattern observed by Lee (1976, b). Lee had shown that variables which affected recall of critical letters as a pair did not affect recall of critical items individually.

Results of an ANOVA on the arc-sin transformation of the probability of recall of at least one letter of the critical pair revealed the following significant main effects: Letter set of critical item (F= 30.72, d.f. 1.18, $P < 0.001$); Repetition (F= 32.46, d.f. 1, 18, $P < 0.001$); Lag (F= 41.21, d.f. 1, 18, $P < 0.001$) and Context (F= 7.55, d.f. 1, 18, $P < 0.025$). The direction of these effects was identical to what had previously been observed with the analysis of recall of both letters of the critical pair. The following interactions were also significant: Repetition X Lag (F= 8.27, d.f. 1, 18, $P < 0.025$); Letter set of critical item X Repetition (F= 6.52, d.f. 1, 18, $P < 0.025$); Letter set of critical item X Context (F= 7.64, d.f. 1, 18, $P < 0.025$) and Repetition X Context (F= 6.30, d.f. 1.18, $P < 0.025$). Only the last of these four interactions had not previously been observed in the analysis on the recall of both letters of the critical pair; this is shown in Figure 1.7. Directions of the all the other effects were as before.

Two interactions involving noise were also significant. Again, the first of these was the interaction between Letter set of

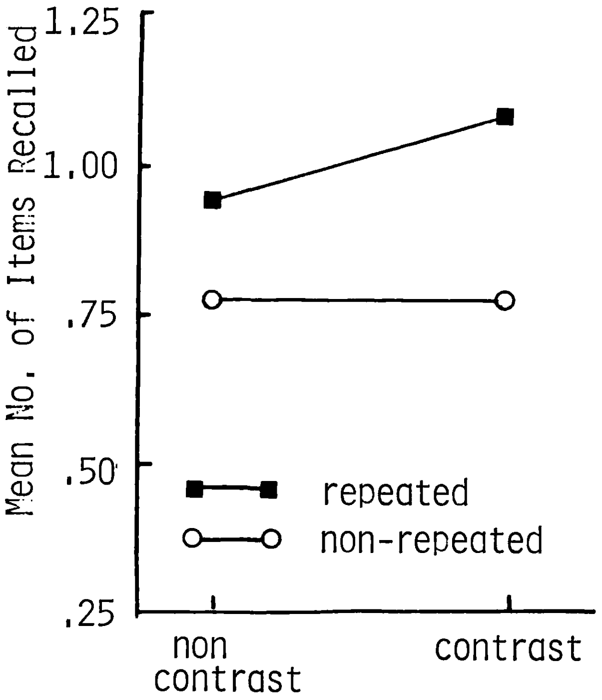

Figure 1.7

Recall of at least one critical letter from a repeated or a non-repeated pair presented in a non-contrasting or contrasting context.

critical item, Context and Noise ($F = 18.61$, d.f. 1, 18, $P < 0.01$). The pattern of this effect was identical to that previously observed (see Figure 1.8). The second interaction included the factors Letter set of critical item, Lag, Context and Noise ($F = 5.00$, d.f. 1, 18, $P < 0.05$). This effect is shown in Figure 1.9. This was interpreted as follows: taking the non-contrasting conditions first, the usual influence of 85 dBC noise impairing recall of acoustically dissimilar letters was observed. These effects were more marked at Lag 0 for both types of items, than at Lag 2. However, in the contrasting conditions dissimilar items at Lag 0 improved under 85 dBC noise. All other conditions showed an impairment. This result further supports the tendency for acoustically similar letters to be helped by loud noise, particularly when the context letters also happen to be of the same type. It is possible that the improvement shown by dissimilar letters at Lag 0 in the 85 dBC conditions is due to the added attention this item receives at input.

DISCUSSION

Results from this experiment generally confirmed the effect demonstrated by Wilding and Mohindra (1980), where it was shown that 85dBC, compared to 65 dBC white noise, improved recall of lists containing acoustically similar letters while having little or no effect on lists containing non-confusable items.

What about the hypothesis under test, i.e. that noise prolonged stimulus traces? No evidence was found to show that any facilitation took place in the recall of repeated items presented

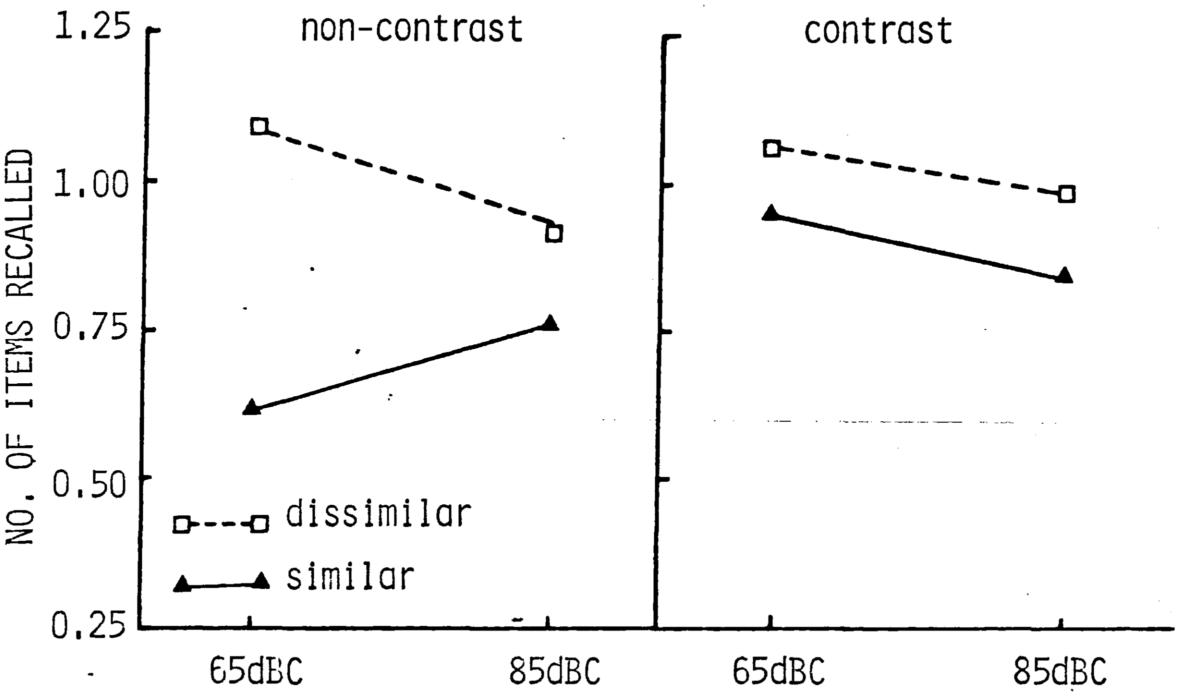

Figure 1. 8. Recall of at least one critical letter (acoustically similar or dissimilar) presented in a non-contrasting or contrasting context under each level of noise.

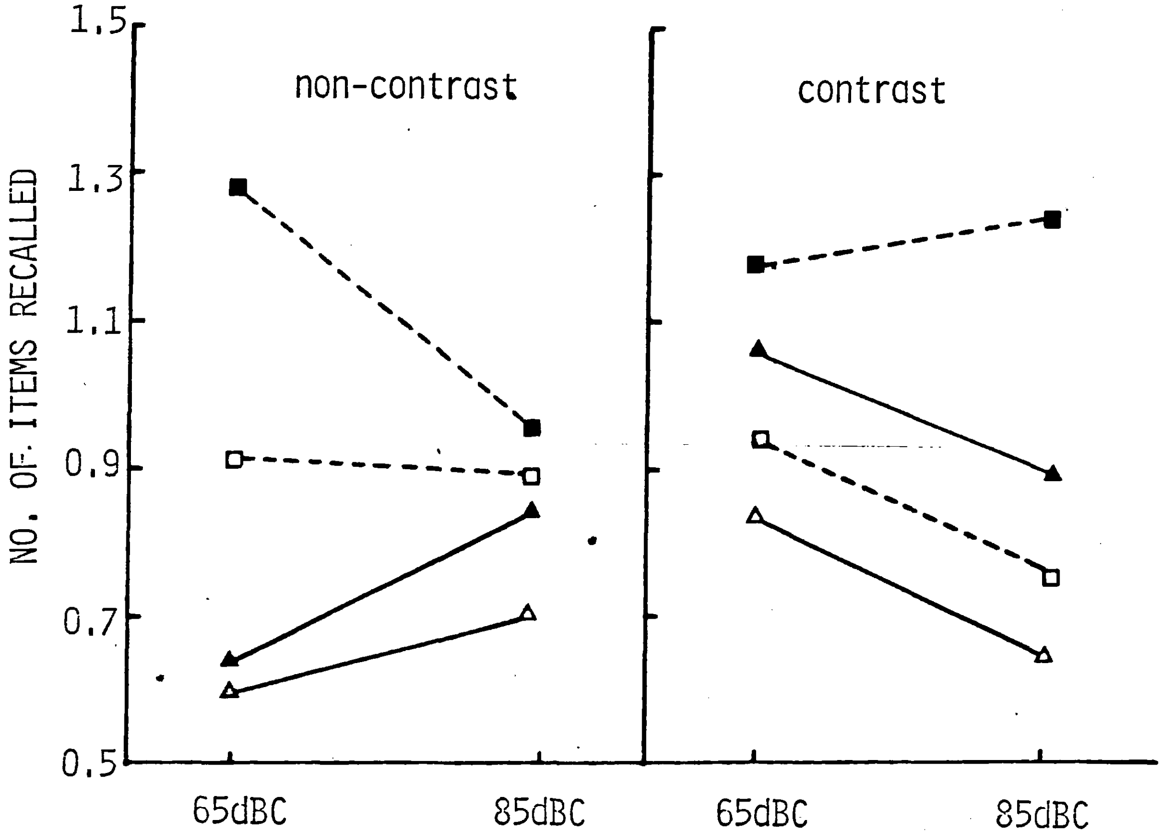

Figure 1.9. Recall of at least one critical letter (acoustically dissimilar Lag 0 ■--■, dissimilar Lag 2 □--□, similar Lag 0 ▲—▲, similar Lag 2 △—△) presented in a contrasting or non-contrasting context under each level of noise.

with more intervening items between repetitions. Instead the pattern of results found here showed that variables such a repetition and acoustic contrast had similar effects on the recall of both letters of a critical pair and on the recall of at least one letter of the critical pair, suggesting that these variables influenced recall by affording differential attention to repeated or to acoustically contrasting letters. In addition noise was shown to enhance this process by promoting further discrimination between items within a list. This does not in itself help recall of repeated items, except in the case of acoustically similar items, which were repetitions and were presented in a non-contrasting context. However, as was discussed previously, the latter result could also be attributed to the overall improvement in recall for acoustically similar lists presented in noise.

In general then these results agree with an interpretation based in terms of the Von Restorff effect. This effect has been described as a facilitation in recall of items that stand out as unique in a series, due to the extra attention or rehearsal they receive (Potts and Shiffrin, 1970). Lee (1976, b) in contrast had shown that critical letters tended to be recalled as units when they were repeated or when they stood out from their background. In her case though, neither of these factors influenced the probability of recalling one letter of the critical pair. This led her to suggest that some stimulus attribute of the critical letter pair was encoded, and that recall of both letters of a pair was facilitated when a tag was retrieved using one letter of the pair of items. In the current experiment however, such an interpretation has to be dismissed, and in any case there there are a number of plausible reasons why the results obtained here may differ from those of Lee. Firstly, in the current experiment critical letters were always presented in the same position in all lists. Over trials subjects may have learned that items presented in these positions have a special relevance and thus may have payed more attention to them. Secondly, the presentation time in Lee's experiment was faster than that used here. Therfore subjects would have had more time in the present experiment to attend to critical items. Thirdly the method by which subjects recorded their response differed in the two experiments. In the experiment by Lee, responses were to be recorded in open boxes, the last letter or any other letter could thus have been recorded first as long as it was placed in the appropriate box. In the present case the response always had to be recorded serially, with the item in the first serial position being entered first, although subjects did have the option of correcting their response at any stage. This may have encouraged more attention to be paid to early list items. Finally the greatest difference that existed between the two experiments was that in the present experiment the to-be-remembered items were accompanied by exposure to white noise. Thus, as pointed out before, enough differences existed to justify the difference in the obtained results.

The next experiment to be described made one change in the procedure, in order to enhance the conditions under which the prolongation of trace duration could occur.

3.2 EXPERIMENT 2

Introduction

The results of Experiment 1 were explained by suggesting that improvement in performance of items, which had properties which allowed them to be discriminated from other items could be accounted for in terms of the the Von Restorff effect. Research on the Von Restorff effect (sometimes known as the Isolation effect) has generally shown that there is a trade-off in attention between isolated items and the remaining items, resulting in the isolated item being better remembered at the expense of the other list items. (Wallace, 1965).

More recently however, it has been observed that in a list containing isolated items, an overall 'list facilitation effect' can occur (Cimbalo and Pelenero, 1970; Johansson, 1970; Stock, 1970; Cimbalo, Capria, Neider and Wilkins, 1977) particularly if list items are presented simultaneously, rather than by the usual method of successive presentation. Johansson (1970) has offered an explanation for this result by suggesting that the subject's chances of directing his attention are greater during slow simultaneous presentation than during successive presentation because there is more time available for memorizing both the isolated item and the background items and that the isolated item may function as a focal point for the spread of attention to the surrounding items.

These conditions should thus facilitate the benefits accrued by trace duration and should lead to an enhancement in the recall of repeated items presented in adjacent positions and also lead to an extension of the repetition effect over more intervening items.

METHOD

In order to test whether the variable of presentation method would have any effects on the results obtained in Experiment 1, it was decided to replicate the experiment using the simultaneous presentation method. Of greater interest was the question regarding the manner in which noise might possibly interact with the factor of presentation method, particularly in view of findings which show that noise increases attentional selectivity (Hockey and Hamilton, 1970; Hamilton, Hockey and Quinn, 1972; Davies and Jones,1975) by focusing attention on dominant sources of information.

Since the simultaneous method was used for presenting items on this occasion, each seven item list was displayed for a total of 3. 5s (this being the sum of the presentation times for each 7 item sequence used in Experiment 1).

Subjects

Again 20 subjects from all departments in Bedford College volunteered to participate in the experiment. None of the subjects had participated in Experiment 1.

Table 2.1

Mean overall recall per list (Max. Score 3.0 given three repetitions per condition) for all conditions in Experiment 2.

Noise Level	65 dBC		85 dBC	
Context	NC	C	NC	C
Critical letter pairs	Acoustically dissimilar set			
Repeated				
Lag 0	2.629	2.514	2.457	2.457
Lag 2	2.471	2.000	2.229	1.829
Nonrepeated				
Lag 0	2.429	1.986	2.171	1.957
Lag 2	2.643	2.014	2.343	1.814
	Acoustically similar set			
Repeated				
Lag 0	2.100	2.643	2.014	2.614
Lag 2	1.971	1.857	2.371	2.200
Nonrepeated				
Lag 0	1.686	2.214	1.843	2.014
Lag 2	1.929	2.329	1.757	2.200

RESULTS

Table 2.1 shows the mean number of letters recalled under all the conditions in this experiment. The results of an ANOVA on the data showed significant main effects due to: Nature of the critical pair- repeated or non-repeated ($F= 13.587$, d.f. 1, 18, $P < 0.01$); Letter set of critical pair-acoustically similar or dissimilar ($F= 12.46$, d.f. 1, 18, $P < 0.01$) and serial position ($F=54.43$, d.f. 6, 108, $P< 0.001$). Direction of effects showed that lists containing repeated items were better recalled as were lists containing acoustically dissimilar items, in comparison to lists containing non-repeated items or acoustically similar items. A normal serial position effect was observed. In addition there were many significant interactions and a table summarizing these can be found in the appendix. In general the effects observed here were similar to those observed in Experiment 1, but a detailed search through the significant interactions showed a notable exception in that noise did not occur as a factor in any of them.

In order to compare overall performance as observed in Experiment 1 with that observed here, a further ANOVA was carried out on the data from the two experiments, which included Experiment as an additional between-subjects variable. The results of this analysis showed that overall performance was higher in Experiment 2 ($F=9.87$, d.f. 1, 36, $P< 0.01$) by about 13%, this effect was the same regardless of whether the lists contained or did not contain repetitions. Furthermore an interaction of Noise X Letter set of critical items X Context ($F=9.45$, d.f. 1, 36, $P <0.01$) also reached significance and showed that there was a general improvement in the recall of acoustically similar items presented in a non-contrasting context during the loud noise conditions, in comparison to an impairment in noise in all other conditions. However, in view of a four-way interaction of Experiment X Noise X Letter set of critical items X Context ($F= 2.75$, d.f. 1, 36, $P = 0.1$) which just failed to reach significance, it is probable that the three-way interaction mentioned above is more likely to be representative of the data contained in Experiment 1 rather than those of Experiment 2. No other Noise X Experiment interactions reached significance.

Recall of both letters of the critical pair.

All effects achieving significance on the ANOVA are shown in Table 2.2. From this it is evident that apart from the lack of any interactions with the factor of Noise, the pattern of results obtained is identical to that observed in Experiment 1, using successive presentation.

Recall of at least one letter of the critical pair.

Table 2.3 summarizes the significant effects for recall of at least one critical letter. As found in Experiment 1 the results show that the stimulus properties and presentation conditions that affect recall of critical letters as a pair also affect recall of individual critical letters. Again this result contradicts that of Lee (1976, b) and suggests that the situation occurring in this experiment can be explained simply in terms of recall being affected by differential attention being allocated to items which stand out from their background. It will be noted that when recall of at least 1 critical letter is scored, in addition to the interactions observed when scoring recall for both letters of a critical pair that the following two interactions also reached significance. First of these was the interaction of Repetition X Context ($F= 8.277$, d.f. 1, 18, $P < 0.025$). The second was the three-way interaction between Repetition, Context and Lag ($F= 8.918$, d.f. 1, 18, $P< 0.01$). This showed that there was a

Table 2. 2

A Summary of the significant effects observed on an ANOVA of the recall of both letters of the critical pair.

1. Letter set of critical pair	F=25. 462,	d.f. 1, 18,	$P < 0.001$
2. Nature of critical pair (Repetition)	F=22. 639,	d .f. 1, 18,	$P< 0.001$
3. Lag	F=35. 475,	d.f. 1, 18,	$P < 0.001$
4. Repetition X Lag	F= 8. 219,	d.f. 1, 18,	$P < 0.025$
5. Letter set of critical pair X Context	F= 7. 835,	d.f. 1, 18,	$P < 0.025$

Table 2. 3

A summary of the significant effects observed on an ANOVA of at least one letter of the critical pair

1. Letter set of critical pair	F=28. 768,	d.f. 1, 18,	$P < 0.001$
2. Nature of critical pair (Repetition)	F=12. 340,	d.f. 1, 18,	$P < 0.01$
3. Lag	F=10. 133,	d.f. 1, 18,	$P < 0.01$
4. Context	F= 5. 874,	d.f. 1, 18,	$P < 0.05$
5. Repetition X Lag	F= 6. 792,	d.f. 1, 18,	$P < 0.025$
6. Letter set of critical pairXContext	F= 7. 433,	d.f. 1, 18,	$P < 0.025$
7. Repetition X Context	F= 8. 277,	d.f. 1, 18,	$P < 0.025$
8. Repetition X Lag X Context	F= 8. 918,	d.f. 1, 18,	$P < 0.01$

marked improvement for repeated items, at Lag 0, presented in a contrasting context while items in all three of the other conditions showed either a slight impairment or a slight improvement. This again supports earlier findings that items which were distinguishable from their background are better recalled.

DISCUSSION

It was shown that when list items are presented using a method of simultaneous presentation method, overall recall is higher than by the method of successive presentation. With regard to the question of whether presentation method changes recall of pairs of items that are repetitions in a context of once presented letters, or pairs that are members of an acoustical set that contrasts with the rest of the sequence, no differences were observed from the results obtained in Experiment 1. Results obtained from scoring recall of at least 1 letter of a critical pair showed that the factors of repetition, letter set of critical item and context played just as crucial a role as they did when recall of both letters of a critical pair was analysed. These results are therefore identical to those observed in Experiment 1 and as such, confirm the interpretation based in terms of the Von Restorff effect.

However the most interesting result (or non-result) to emerge from this experiment was the general absence of the effects of loud noise on recall as observed in Experiment 1. This lack of an effect of noise cannot be explained in terms of recall reaching a ceiling when simultaneous presentation is used because percentage recall over the whole list was 72%, compared to 50% when the successive presentation method was used, which therefore still leaves enough room for improvement or impairment to occur. What was even more surprising was the total lack of an interaction of Noise and type of stimuli (acoustically similar or dissimilar), particularly in view of previous consistent findings showing that noise improves performance of acoustically similar items. This pattern of findings thus suggests that the effects of noise are in some way connected with the processes which operate at the encoding or organizational stages of information processing.

Mackworth (1963) noted that reading rate for letters is 3.0 letters per second. With this estimate in mind it can be assumed that during the simultaneous presentation conditions there is enough time available for more than one reading per item; this would not be possible in successive presentation conditions where the next item is not available for reading until presentation time for the item currently on display has elapsed. Assuming that rate of rehearsal is related to rate of reading (an assumption also made by Baddeley, Thomson and Buchannan, 1975) it is suggested that noise effects may be restricted to where the need for rehearsal is maximized, in which case those may well be the type of conditions under which a phonological representation of the items to be remembered is necessary for generating a rehearsal response. It is therefore suggested that the failure to observe any noise effects in Experiment 2 could well be attributed to there being more time available to process items in a manner which does not rely on rehearsal. Furthermore it has been suggested by Chase

(1977) that rehearsal rate for acoustically confusable items is upto 25% slower than that for non-confusable items, thus implying that recall for these items will be poorer when restrictions are placed on the time available for their rehearsal. However it is the recall performance of these particular items which improves in noise, relative to the quiet conditions, using a successive presentation method. Why this should be will be examined in more detail in later experiments presented in this thesis.

3.3 EXPERIMENT 3

Introduction

The results of the last two experiments showed that the method of presentation of items was one of the most crucial variables influencing the nature of noise effects on serial order recall. A consideration of the processes underlying serial order recall reveals that rehearsal is the most frequently used strategy for maintaining information in short term memory. As was discussed in Chapter 2, there are differences in the opportunity for rehearsal when different methods of stimulus presentation are used. The opportunity, and possibly the rate of rehearsal, using a method where all the to-be-remembered letters are presented simultaneously are obviously greater than when all the items are presented successively. However as pointed out by Chi (1976), it is important to remember that rehearsal is a time dependent process and that subjects may engage in rehearsal only if there is time left between stimulus presentations. This would suggest that if stimuli are being presented successively at a fast, as opposed to a slow rate of presentation, there would be less opportunity for rehearsal. If, in addition, we also assume that information presented in the visual modality is transformed into some type of phonological representation, it could transpire that at a rate of presentation which is fast enough to preclude rehearsal, the availability of a phonological code is unlikely or will be restricted. However provision of a sizeable delay prior to recall could provide the necessary time for the construction or enhancement of a phonological code (Estes, 1973).

By designing an experiment which manipulated the variable of presentation rate and delay prior to recall, it is hoped that it would be possible to pinpoint the process on which the effects of noise operate. The predictions would be that if noise effects are observed when the opportunity for rehearsal is limited, i.e. at very fast rates of presentation, this would suggest that noise affects the stage at which information is input into the system. If, on the other hand, noise effects occur only at slower rates and in conditions where there is a delay prior to recall, this would suggest that noise affects the stage at which information is transformed from a visual representation in which it is first encountered to a phonological or articulatory representation, which is used to rehearse and maintain the information in short term memory.

In the next experiment to be described, in addition to manipulating rate of presentation in order to influence opportunity for rehearsal, acoustic similarity of the items to-be-remembered was also varied. According to Baddeley and Hitch (1974), the working memory model attributes the phonemic similarity effect to utilization of the articulatory loop. Therefore, when use of the articulatory loop is restricted through the use of suppression, the phonemic similarity effect disappears. On the other hand, Murray (1965, 1966, and 1967) has shown that articulating aloud during item presentation or during rehearsal particularly impairs retention of acoustically similar items. Wilding and Mohindra (1980, Experiment 2) have qualified this result by showing that the harmful effects of articulation for acoustically similar items are more marked at a slow rate of presentation (2s per item as compared to ½s per item). At the fast rate of presentation articulating items aloud during presentation actually improved performance of acoustically similar items, relative to their performance in non-articulating conditions. Exposure to 85 dBC, instead of 65 dBC white noise, also benefitted recall of acoustically similar items but failed to show a significant effect of noise when added to articulation. On the whole the findings of Wilding and Mohindra showed that the main difference between the effects of noise and articulation in their interaction with the acoustic similarity effect was that noise improved performance on the recall of acoustically similar items while articulation impaired it, but only at the slow rate of presentation.

Presentation of items at a rate which would preclude articulation during item presentation was thus compared to conditions where items were presented more slowly. Also in some trials a delay following the presentation of the list was allowed, in the hope that the remaining visual trace could be converted to an articulated form.

METHOD

Subjects

Twenty subjects, ten in each noise condition, took part in the experiment. They were students attending Bedford College who had participated approximately two weeks prior to the present study, in similar experiments reported by Wilding and Mohindra (1980). Subjects were thus highly practised in doing this type of task.

Design and Materials

The stimuli used in this experiment were identical to those used by Wilding and Mohindra (1980, Experiment 2), the only difference between the two experiments being the rate at which items were presented in the current study. Here items were presented either at a rate of 6 items per second(fast rate) or a rate of 2 items per second (slow rate here but equivalent to the fast rate in the Wilding and Mohindra experiment). In order to ensure that the display time per item was comparable in the two presentation rates, items were always displayed for a total of

1/12 of a second per item. Inter item intervals, during which time the display screen remained blank however varied; for the fast rates of presentation an interval of 1/12 s was used while for the slow presentation rate an interval of 5/12 s was used.

Procedure

The procedure was identical to that used by Wilding and Mohindra, with items being presented on the screen of a CBM 'PET' microcomputer.

Five letters were presented in each case. The independent variables were noise level (65 or 85 dBC), subjects being randomly assigned to one or the other level, articulation (articulate or don't articulate during presentation of items), acoustic confusability (acoustically similar or dissimilar items), recall delay (short or long these being $1\frac{1}{2}$ s or 8 s respectively), and rate of presentation (fast or slow as described earlier). Instructions were similar to those presented in Experiment 1 and subjects responded by typing in the letters on the keyboard of the computer.

RESULTS

The results consisted of the probability of correct response for each of the five serial positions in the 16 conditions given to each subject (articulation X delay X rate of presentation X acoustic similarity). A split plot ANOVA was carried out on the data with all effects being tested against their interaction with subjects except in the case of effects involving noise which were tested against the corresponding subjects-within-noise term.

Main effects of rate of presentation ($F = 28.67$, d.f. 1, 18, $P < 0.001$), acoustic similarity ($F = 26.52$, d.f. 1, 18, $P < 0.001$), and serial position ($F = 70.07$, d.f. 4, 72, $P < 0.001$) were all significant. Performance was best at the slow rate of presentation compared to the fast, for acoustically dissimilar items rather than for the similar items and showed the normal serial position effect. A significant interaction of Rate of presentation X Acoustic similarity ($F = 4.3$, d.f. 1, 18, $P < 0.05$, on a one tailed test) showed the predicted reduction in the phonemic similarity effect at the fast rate of presentation. Thus the difference in recall between acoustically dissimilar and similar items was much greater at the slow rate of presentation than at the fast rate. This confirms the hypothesis that use of a phonemic or articulatory representation was reduced under the fast rate of presentation.

Also several interactions including serial position as a factor reached significance. They were as follows: Articulation X Position ($F = 2.64$, d.f. 4, 72, $P < 0.05$); Rate of presentation X Position ($F = 5.43$, d.f. 4, 72, $P < 0.01$); Delay X Position ($F = 3.84$, d.f. 4, 72, $P < 0.01$); Acoustic similarity X Position ($F = 10.98$, d.f. 4, 72, $P < 0.001$) and finally Articulation X Acoustic similarity X Position ($F = 3.86$, d.f. 4, 72, $P < 0.01$). Taking each one in turn these effects can be described as follows: Articulation improved performance in all positions except the first, delay had similar effects with performance being better at longer delays and markedly so for the last two serial positions. The effects of rate of presentation were as expected with the slower rate improving performance over all serial positions except the first. Finally acoustic similarity showed a large effect with dissimilar letters being recalled better than similar letters in all serial positions, the size of the difference increasing directly with position.

For the Articulation X Acoustic similarity X Position interaction it was apparent that articulation helped performance of both types of list but that its greatest benefit was for acoustically similar items presented in serial positions 4 and 5. None of the factors mentioned so far entered into higher order interactions other than those already reported.

Turning now to a consideration of the effects of noise it was found that although the main effects of noise were not significant, noise did enter into a significant interaction with Delay and Position (F= 2.61, d.f. 4,72, $P < 0.05$). This is shown in Figure 3.1. From looking at this interaction it is apparent that the superior performance in 85 dBC noise is greater at the longer delays as opposed to with the shorter delays for later serial positions (positions 3, 4 and 5). This result was interpreted as showing that a long delay after stimulus presentation helps in the recall of items and that exposure to noise in these conditions further enhances performance particularly of later items. It is further suggested that subjects use the delay to produce a phonological representation, from the resultant visual trace, and on the basis of this engage in maintenance rehearsal. Noise thus seems to enhance this process in some way

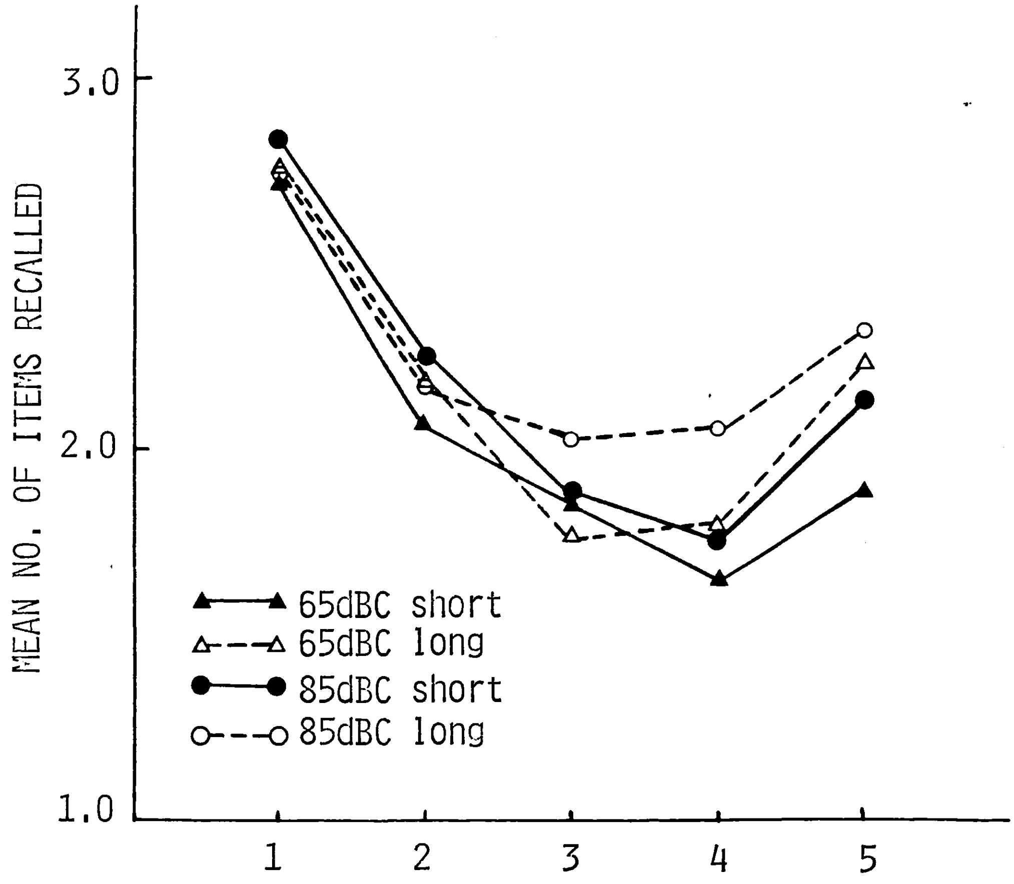

Figure 3.1 Mean number of items recalled in all serial positions, under the two levels of noise, after long or short delays.

Table 3.1 **Mean number of items recalled per list (Max. score 3.0) in all conditions in Experiment 3.**

Noise Level		65dBC				85dBC			
Delay		SHORT		LONG		SHORT		LONG	
Acoustic Similarity		C	NC	C	NC	C	NC	C	NC
Articulation Rate									
No Artic.	Fast	1.50	1.90	1.44	2.14	1.84	2.06	1.56	2.36
	Slow	1.86	2.52	2.08	2.78	2.02	2.80	2.30	2.86
Artic.	Fast	1.60	2.08	1.84	2.14	1.82	1.96	2.00	2.24
	Slow	2.14	2.70	2.10	2.66	2.14	2.82	1.92	2.90

with the result that overall recall is improved.

Noise did not enter into interactions with either rate of presentation or with acoustic similarity. Although it was predicted that the phonemic similarity effect would be negligible at the fast rate of presentation, this does not explain why no noise effects were observed on acoustically similar items at the slow rate of presentation. However closer analysis of the non-significant Noise X Rate of presentation X Acoustic similarity interaction showed that for the acoustically dissimilar items at least, performance was almost at ceiling levels. Although this was not the case in the fast presentation conditions it was decided that the experiment should be replicated using a group of naive subjects instead of the highly practised group which had been used here. It was felt that perhaps as a result of the practise these subjects may have developed alternative strategies in order to perform the task.

3.4 EXPERIMENT 4

METHOD

Subjects

Twenty subjects, from various departments at Bedford College, volunteered to participate in this experiment. None of these subjects had taken part in any of the experiments reported by Wilding and Mohindra (1980) or in any of the experiments reported in this thesis so far.

Design and Procedure

In all respects, conditions in this experiment were identical to those in Experiment 3.

RESULTS

An ANOVA was carried out on the data, again in exactly the same manner as described in Experiment 3. For table of means see page 96.

Table 4.1 shows a comparison of the effects which reached significance in both Experiment 3 and Experiment 4. Of the main effects, only the effect of Articulation had not previously been observed. This showed that articulation improved performance relative to the no-articulation conditions; the direction of the other main effects was as before. In addition to the above, first order interactions of Rate of presentation X Acoustic similarity and of Acoustic similarity X Position were also significant and were as had previously been observed.

Unlike the situation in Experiment 3, the effect of Delay X Noise ($F = 4.61$, d.f. 1, 18, $P < 0.05$) reached significance in the present experiment. This interaction is shown in Figure 4.1. Here it was observed that noise had a slight effect at short delays and a larger effect at long delays. This combination of the loud noise and the long delay conditions had also yielded the best performance in Experiment 3, but there, no interaction had been observed between the two factors since the longer delay had improved performance under both levels of noise. This would suggest that the more sophisticated subjects participating in Experiment 3 had utilized the delay interval to their advantage

Table 4.1

Significant effects observed from an ANOVA of data obtained in Experiment 3.

1. Rate of presentation (Rate)	$F=28.67$,	d.f. 1,18,	$P < 0.001$
2. Acoustic similarity (Confusion)	$F=26.52$,	d.f. 1,18.	$P < 0.001$
3. Serial Position (Position)	$F=70.07$,	d.f. 4,72,	$P < 0.001$
4. Rate X Confusion	$F=4.3$,	d.f. 1,18,	$P < 0.05$
5. Rate X Position	$F=5.43$,	d.f. 4,72,	$P < 0.01$
6. Articulation X Position	$F=2.64$,	d.f. 4,72,	$P < 0.05$
7. Delay X Position	$F=3.84$,	d.f. 4,72,	$P < 0.01$
8. Confusion X Position	$F=10.98$,	d.f. 4,72,	$P < 0.001$
9. Articulation X Confusion X Position	$F=3.86$,	d.f. 4.72,	$P < 0.01$
10. Delay X Position X Noise	$F=2.61$,	d.f. 4,72,	$P < 0.05$

Significant effects observed from an ANOVA of data obtained in Experiment 4.

1. Articulation	$F=7.61$,	d.f. 1,18,	$P < 0.025$
2. Rate	$F=26.86$,	d.f. 1,18,	$P < 0.001$
3. Confusion	$F=101.6$,	d.f. 1,18,	$P < 0.001$
4. Position	$F=66.73$,	d.f. 4,72,	$P < 0.001$
5. Rate X Confusion	$F=9.33$,	d.f. 1,18,	$P < 0.01$
6. Rate X Position	$F=5.20$,	d.f. 4,72,	$P < 0.01$
7. Confusion X Position	$F=10.8$,	d.f. 4,72,	$P < 0.001$
8. Rate X Confusion X Position	$F=2.71$,	d.f. 4,72,	$P < 0.05$
9. Artic. X Delay X Confusion X Post.	$F=3.26$,	d.f. 4,72,	$P < 0.025$
10. Delay X Noise	$F=4.61$,	d.f. 1,18,	$P < 0.05$
11. Artic. X Rate X Confusion X Noise	$F=4.91$,	d.f. 1,18,	$P < 0.05$

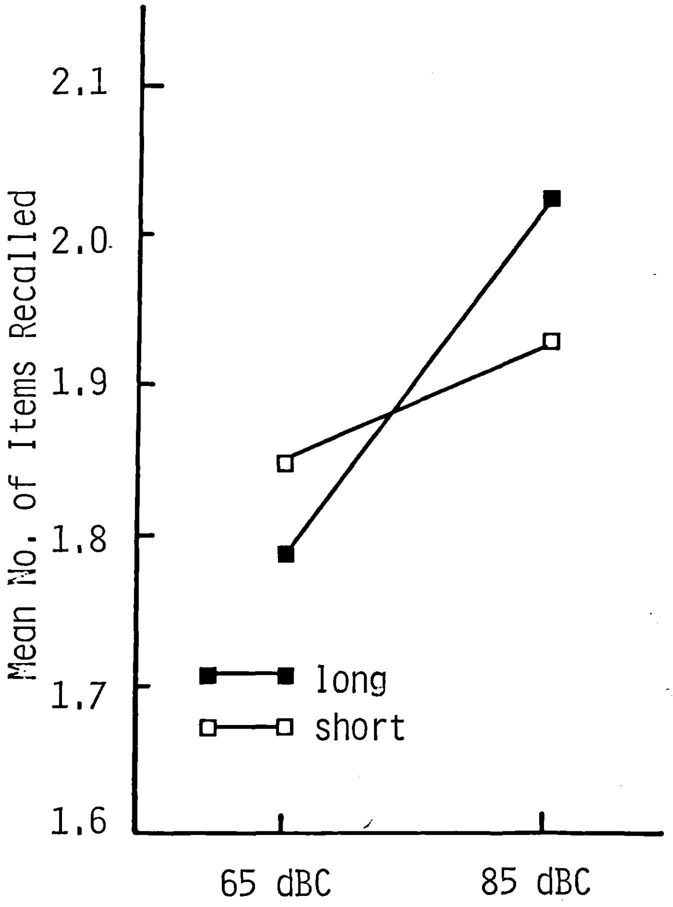

Figure 4.1.

Mean number of items recalled after either long (8s) or short ($1\frac{1}{2}$s) delays under each level of noise.

Table 4.2 **Mean number of items recalled per list (Max. score 3.0) in all conditions in Experiment 4.**

Noise Level		65dBC				85dBC			
Delay		SHORT		LONG		SHORT		LONG	
Acoustic Similarity		C	NC	C	NC	C	NC	C	NC
Articulation Rate									
No Artic.	**Fast**	**1.32**	**1.84**	**1.24**	**1.86**	**1.52**	**1.82**	**1.46**	**1.90**
	Slow	**1.60**	**2.38**	**1.56**	**2.26**	**1.62**	**2.74**	**1.60**	**2.44**
Artic.	**Fast**	**1.46**	**2.10**	**1.62**	**1.74**	**1.40**	**1.84**	**1.80**	**2.14**
	Slow	**1.44**	**2.64**	**1.46**	**2.54**	**2.00**	**2.50**	**2.02**	**2.86**

in both noise conditions. This was confirmed to some extent by the higher level of overall recall observed in Experiment 3.

Other significant two-way interactions included those of Rate of presentation X Acoustic similarity ($F = 9.3$, d.f. 1, 18, $P < 0.01$); Rate of presentation X Position ($F = 5.2$, d.f. 4, 72, $P < 0.01$) and Acoustic similarity X Position ($F = 10.8$, d.f. 4, 72, $P < 0.001$). However all these were superseded by the three way interaction between Rate of presentation X Acoustic similarity X Position ($F = 2.71$, d.f. 4, 72, $P < 0.05$) which is shown in Figure 4.2. Here it will be seen that whereas acoustically dissimilar items presented at the slow rate showed performance almost at ceiling level for all items in the list, the remaining conditions showed a normal serial position effect, with performance being poorest for acoustically similar items presented at a fast rate. This replicated the picture observed previously.

One last interaction which was particularly interesting was that between Articulation, Rate of presentation, Acoustic similarity and Noise ($F = 4.91$, d.f. 1, 18, $P < 0.05$). This is shown in Figure 4.3. This showed that a marked improvement in recall for items presented in 85 dBC noise occurred for acoustically similar items presented at a slow rate during conditions requiring overt articulation. On the remaining conditions performance in loud noise was either similar to, or slightly better than in quiet noise conditions. One other notable feature of this interaction was that recall performance during articulation was generally superior to

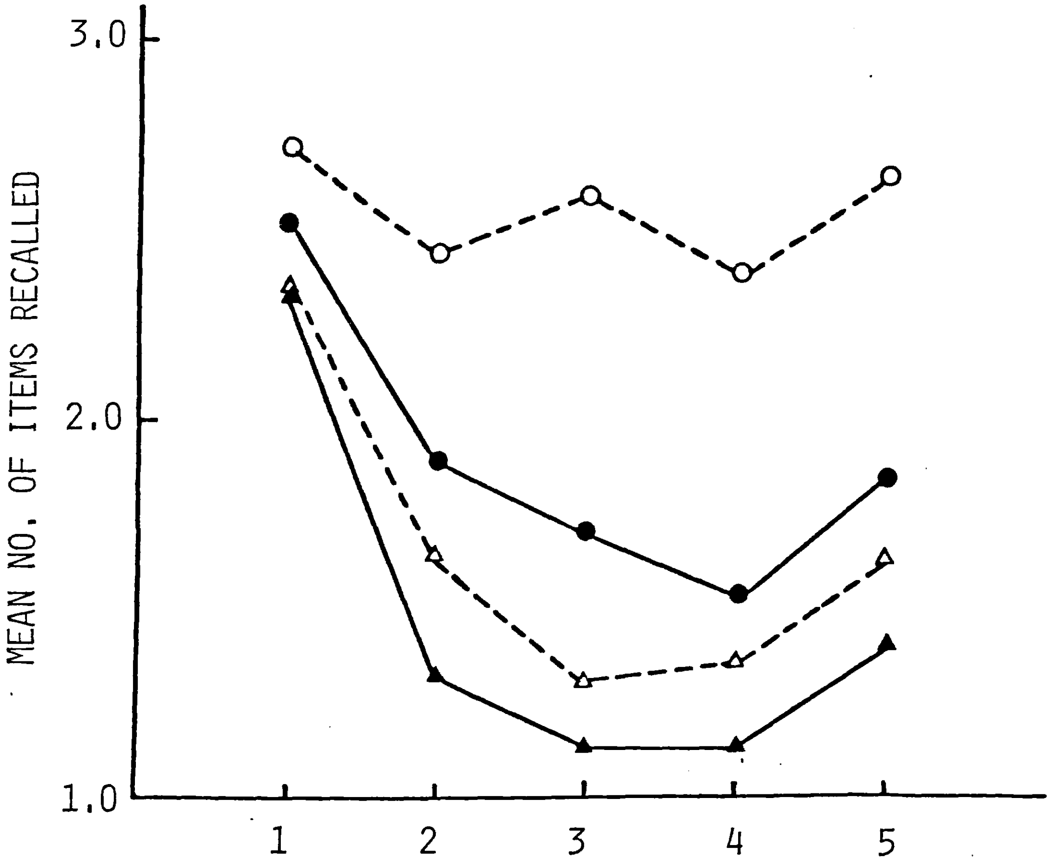

Figure 4.2

Mean number of items recalled at different combinations of acoustic similarity and rate of presentation in all serial positions (Slow Non-conf.○---○, Fast Non-conf.●—●, Slow Conf.△---△, Fast Conf.▲—▲).

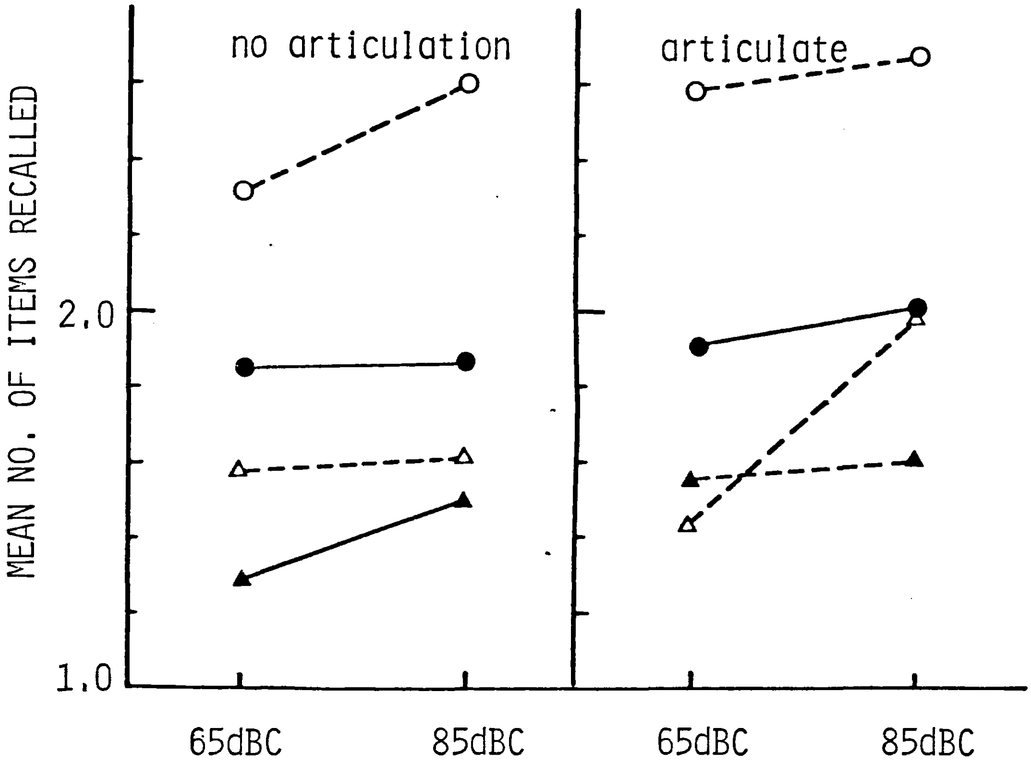

Figure 4.3.

Mean number of items recalled at different combinations of acoustic confusability and rate of presentation (Slow Non-conf.o---o, Fast Non conf.●——●, Slow Conf.△---△, Fast Conf.▲——▲) in articulation and no-articulation conditions under each level of noise.

the no-articulation conditions. This result confirms Wilding and Mohindra's (1980) finding that noise improved recall for acoustically similar items and also that some improvement occurred when loud noise was added to articulation. This effect was particularly evident when the rate of presentation of items was equivalent to the slower of the two rates used in the current experiment (i.e. 2 items per second). As pointed out by Wilding and Mohindra, this finding suggests that at this rate of presentation, articulating the items aloud is a convenient strategy, consistent with what subjects might do subvocally when left to their own devices. On the basis of these findings it is suggested therefore that articulation (overt or covert) for the purpose of rehearsal and for eliciting a phonological representation, is a useful strategy and that should these conditions be present simultaneously, noise will have the types of effects described above of improving serial order performance.

GENERAL DISCUSSION

The results of experiments 3 and 4 provide strong evidence the rehearsal process plays a critical role in maintaining serial order information and that time has to be made available for this process to take place. Therefore if stimuli are presented at a rate which reduces the opportunity for rehearsal to take place, memory for such items is at best very poor. These conditions however do create conditions where the phonemic similarity effect is least apparent. On the other hand, provision of a delay prior to recall is all that is required to provide the opportunity for rehearsal to occur and subjects presumably utilize this interval to construct a phonological representation on the basis of which order information is maintained. This would support the general conclusions drawn by Crowder (1978) who suggested that "phonological coding will be evident to the extent that subjects have had a recent opportunity for rehearsal". Further, as shown by Healy (1975) phonological coding is a specialised device used for the retention of temporal order information, particularly when this information is presented in the visual modality.

These circumstances appear also to be necessary for noise effects to be observed on serial order memory. Some stage of the conversion of visual information to a phonological representation, or of the holding process thus seems to be implicated. Both the experiments just reported demonstrated that noise improved performance in conditions where a long delay was present before recall or in conditions where it was possible to rehearse during the inter-stimulus interval between items. Further it was observed that noise also improved performance of acoustically similar items, particularly if overt articulation of the items was engaged in by the subjects. This confirms the suggestion made by Wilding and Mohindra (1980) that noise and articulation affect serial order recall in the same way, but that suppression and noise are certainly not alike. This implies then that should there be no opportunity for rehearsal, then no noise effects should be observed.

This interaction of the effects of noise with the opportunity for rehearsal was investigated again in the next experiment using a different memory paradigm - a recognition memory paradigm, before further attempts were made to elucidate more specifically what effect noise had on the rehearsal process itself.

CHAPTER 4

THE EFFECTS OF NOISE AND TEST EXPECTATIONS IN RECALL AND RECOGNITION

EXPERIMENTS 5 & 6

On reviewing the literature it became immediately apparent that not many studies have looked at the relationship between arousal and recognition memory performance. Levonian (1967) showed his subjects a traffic safety film without telling them that measures of retention would be required. GSR measures were taken while the film was being presented. A recognition questionnaire was adminstered immediately following the film and also one week later. High arousal items showed poorer short term and better long term recognition relative to low arousal items and the interaction between arousal and retention interval was also significant.

Archer and Margolin (1970) were interested in looking at the effects of arousal on intentional remembering and forgetting. They gave an immediate recognition test after presenting their subjects with lists of numbers, each of which was followed by a "remember" or "don't remember" instruction. A facilitation was shown for those items which were presented in white noise and particularly for items associated with the remember instructions.

Schwartz (1974) presented short stories containing a number of surnames in the presence of different levels of white noise. On an immediate recognition test subjects were required to indicate whether probe surnames were correct and to give a rating of confidence in their judgement. Using a signal detection analysis Schwartz found that noise influenced both the parameters d' and β. More precisely, in quiet conditions, subjects tended to employ significantly more cautious criteria for rare surnames and riskier criteria for common surnames. In noise however, subjects adopted similar criteria for both classes of surnames. These results were interpreted by Schwartz as supporting the hypothesis that arousal affects the accessibility of information for retrieval.

Eysenck (1974, 1975) has also proposed that the processes involved in the retrieval of information should be taken into account when considering the effects of arousal. Eysenck tested performance on a semantic memory task using a recall and a recognition paradigm where subjects had to produce a word from a specified category whose name started with a particular letter, for example "fruit - A (recall), or they had to respond 'yes' if the category name was followed by a member of that category, and 'no' if it was not (recognition). Arousal was manipulated by means of individual differences on the extraversion scale of the E. P. I. and on the General Activation scale of the Thayer adjective checklist (1967). Subjects judged to be high on arousal responded fastest on the recognition trials; recall, however, was affected by the dominance of the information tested. High arousal subjects produced a faster response for dominant items with dominance associated with any item pair being determined by reference to the Battig and Montague (1969) norms. With respect to noise however, Eysenck (1975) found no selective influence of 80 dB white noise upon high or low dominance latencies in a semantic recognition task similar to that described above, although he did find that noise inhibited the recall speed of low dominance items, suggesting that noise may have a different effect on recall and recognition.

According to Millar (1979), the recognition task used by Eysenck is not one of pure recognition because it requires a decision about the word's category membership as well as a judgement of its simple name identy. Millar therefore re-examined semantic word recognition by using simple recognition and a wider separation of dominance levels. He used a modified recognition threshold procedure where the target word was back projected and rendered completely undecipherable until the projector gradually brought it into focus. and subjects vocalized the word when confident of its identity. Separate groups performed the task in 95 dBA noise or 70 dBA quiet, and on half the trials the target word's category membership was revealed before its presentation. The recognition of semantically low dominance items was not significantly impaired by noise but the recognition of high dominance words was reliably faster in noise " indicating the vulnerability of even recognition's small retrieval component in arousal".

More recently a great deal of interest has arisen in attempting to understand the differences between the processes of recall and recognition (Brown, 1976). One model, namely the dual process model of recall and recognition, is based on the assumption that recall involves a retrieval stage as well as a decision stage. Accordingly any experimental variable that affects the probability of retrieval should affect recall but not recognition and a variable that affects the decision stage should produce a difference in recall and recognition.

One approach through which it would be possible to look at the effect of noise on these two processes would be to study the effect on processing strategies induced by recall and recognition test expectations. In this type of study subjects are told to expect a recall test or a recognition test and are then given the unexpected one of the two tests. The results of these experiments suggest that the two instructions differ in the extent to which they induce rehearsal, with subjects expecting a recall test tending to engage in more active processing than subjects expecting a recognition test (Hall, Grossman and Elwood, 1976; Hall, Miskiewicz and Murray, 1977; Maisto, DeWard and Millar, 1977; Loftus, 1971). Lewis (1981) reported an experiment in which a 2 X 2 factorial design was used with two types of instructions (recall vs recognition) and two levels of white noise (65 and 85 dBC). A comparison of data from these two groups showed that white noise improved free recall of subjects expecting a recall test and impaired that of subjects expecting a recognition test. On a subsequent recognition test, performance of recall instructed subjects was again improved in 85 dBC noise conditions relative to the recognition instructed subjects. These results were interpreted as suggesting that noise increases rehearsal, particularly when this is required by the task. (i.e. in the recall instructed group).

In the experiment to be reported here, Schwartz's (1974) proposition that arousal facilitates memory based on the physical properties of verbal material, but adversly affects memory for semantic features was investigated in a recognition memory paradigm. Distractor items which were either synonymous with, or acoustically similar to, target items were used to test whether more false alarms occurred with these items in noise in relation to randomly selected distractors.

4.1 EXPERIMENT 5

METHOD

Subjects

34 subjects (mean age 17 years), all sixth formers attending Bedford College on a tour of the Department of Psychology, participated in this experiment. Half of them were randomly assigned to the 65 dBC noise condition and the other half experienced 85 dBC noise. Subjects were tested in two groups of 17 subjects each.

Materials

Five lists of 25 words each, were prepared. The first list consisted of the target items. Lists 2, 3, 4 consisted respectively of words which were synonyms, high associates or words acoustically similar to target items. The fifth list was made up of randomly chosen distractor words matched for word length and frequency of occurrence.

The list of target words was printed in upper case letters and presented on the screen of a video monitor connected to a 'PET' microcomputer with each item being displayed for 1s followed by a 2s gap before the next item. During the presentation of items subjects wore headphones through which white noise of 65 or 85 dBC intensity was played from a tape recorder.

Procedure

Subjects were instructed that a list of words would be presented on the video screen, to look carefully at the words and afterwards be prepared to choose the presented words from a list containing some new and some old words. After all the target words had been presented, subjects turned over a sheet of paper containing the words from all five lists (125 words), arranged in a random order. They were asked to respond 'yes' to those words they had just seen on the video screen and 'no' to any new words. No noise was presented at the recognition stage of the experiment.

RESULTS

The mean number of target items correctly recognized under each level of noise, values of d' and β and the number of false alarms for each distractor type are shown in Table 5.1. Results of an independent t-test ($t = 1.23$, $P > 0.05$) failed to show any significant difference between the number of items recognized in the two noise conditions. Using a signal detection analysis

Table 5.1

Mean values for the Number of words recognized, d', β, and false alarms according to distractability under each level of white noise used in Experiment 5.

Noise Level	Mean no. of words recog.	d'	β	False alarms according to distraction			
				synonym	high assoc.	acoustic similar	random
65 dBC	16.53	2.45	3.51	1.59	2.52	1.52	1.00
85 dBC	18.23	2.79	4.30	1.76	2.41	1.41	1.00

values of d' and β were calculated for the two groups. Mean values for both these parameters were found to be higher in the 85 dBC condition but in neither case were they significantly different from values obtained under 65 dBC noise. An analysis of the false alarms generated under each distractor type showed generally that very few errors occurred and that there was no interaction of noise by type of error.

DISCUSSION

Overall the number of errors was found to be very low and there was no evidence to suggest that noise biased the use of either a semantic strategy or a strategy based on the physical properties of the items.

Since these results lend no support to results obtained from recall tasks, it could be the case, as suggested above, that noise effects only occur in tasks where an active rehearsal strategy is adopted by subjects in order to enhance memory performance. Recognition instructions do not seem to promote such a strategy and subjects possibly allow the information to pass before them without making too much of an effort to organize the material to-be-remembered.

Therefore a second experiment was carried out, but this time subjects were told to expect a recall test after presentation of the list of target items. In addition a 75 dBC noise group was also run in order to test whether the effect of noise followed a linear or a non-linear trend as level of noise increased.

4.2 EXPERIMENT 6

METHOD

Subjects

52 subjects, all sixth formers (mean age 17 years), attending Bedford College on a tour of the Psychology Department participated in this experiment. Subjects were randomly assigned to one of the three (65, 75 or 85 dBC) noise conditions. None of the subjects had participated in Experiment 5.

Stimulus material.

Stimulus material and presentation method were as in Experiment 5.

Procedure

All aspects of the procedure were identical to that of Experiment 5, except that subjects were told that on completion of the list presentation, they would be asked to recall as many of the presented items that they could remember in any order they liked. Subjects were allowed 3 minutes for the recall task which was then followed by an unexpected recognition test presented in an identical manner to that used in Experiment 5.

RESULTS

Table 6.1 shows the mean number of items recalled and the probability of recall in the correct sequence for each of the three noise conditions used.

Table 6.1

Noise Level	Mean number of words recalled.	Probability of recall in the correct sequence.
65 dBC (n=19)	12.32	0.095
75 dBC (n=17)	12.11	0.098
85 dBC (n=16)	12.88	0.146

Analysis of the mean number of words recalled using a 1-way ANOVA failed to show ($F < 1$) a significant effect of noise. This result was not totally unexpected since in a number of previous experiments no differences have been found in the total number of items correctly recalled under different levels of noise (Hormann and Osterkamp, 1966; Daee and Wilding, 1977; Smith, 1980; Wilding, Mohindra and Breen-Lewis, 1982). However a general trend found in free recall studies is the existence of a relationship between noise level and the probability of remembering items in the correct sequence. An increase in sequence recall was also observed here, but (unfortunately) the effect was small and did not reach significance.

Analysis of the recognition scores, means for which are shown in Table 6.2 showed that a non-monotonic relationship

Table 6.2

Mean values for the number of words recognized, d', β, and false alarms according to distractability under each level of white noise used in Experiment 6.

Noise Level	Mean no. of words recog.	d'	β	False alarms according to distraction			
				synonym	high assoc.	acoustic similar	random
65 dBC	17.60	2.36	6.22	1.84	2.63	1.68	1.26
75 dBC	16.50	2.20	5.56	1.82	2.41	1.53	1.41
85 dBC	18.13	2.33	5.05	1.63	2.25	2.25	1.40

existed between the mean number of items recognised and noise level, with recognition being slightly better in 85 dBC noise and poorest in 75 dBC noise. However the results of an ANOVA failed to show that the effect was significant ($F < 1$). Analysis including the false alarm data using the signal detection procedure showed no effects of noise level on the d' parameter and although β values decreased as noise levels increased the linear trend failed to reach significance ($F = 2.35$, d.f. 1,49, $P > 0.05$). When errors were analysed according to distractor type again there was no evidence for an interaction between errors and noise level.

DISCUSSION

There was some indication in the recall scores of a non-monotonic effect of noise, with performance being best under 85 dBC and worst under 75 dBC noise. However this result was not statistically significant and resembles the result obtained by Wilding, Mohindra and Breen-Lewis (1982) with a

30 item list of non-associated words. Probability of recalling words in the correct sequence increased with noise, suggesting that subjects favour a maintenance rehearsal strategy in noise. This particular strategy seems to be adopted quite spontaneously but more especially when subjects are told to expect a recall test after list presentation (Lewis, 1981).

A similar non-monotonic trend in the effect of noise on the recognition scores may also be a reflection of the strategy adopted by subjects expecting a recall test. Again however the error results showed no indication that noise biased use of either a semantic or a physical processing strategy.

GENERAL DISCUSSION

In general, the results of both Experiment 5 and Experiment 6 showed that the number of items recognised was greater when items were presented in loud noise conditions. However in neither case did the difference in the number of items recognised reach significance. Also neither of the experiments reported provided any support for Schwartz's hypothesis that arousal facilitates memory based on the physical attributes of the information and adversely affects memory for semantic features. Since Schwartz himself has obtained evidence confirming this effect in the free recall paradigm, it can only be assumed that either the recognition memory paradigm is not sensitive enough in eliciting these subtle effects or that the conditions of encoding and retrieval which are present during recognition do not resemble those which exist during free recall. In order to match the free recall conditions at encoding, subjects in Experiment 6 were led to expect a free recall test. In this case again recognition performance was not shown to significantly improve with noise level. Recall scores also showed no effects of noise, but this was expected since immediate free recall does not generally show an impairment with noise unless indicators of organizational activity such as measures of category clustering or recall in the correct sequence are used.

It is concluded therefore that the subtle changes on processing strategy which accompany noise effects observed within the free recall paradigm either do not occur within the recognition paradigm or are not open to observation using the method employed in the experiments described here.

CHAPTER 5

NOISE EFFECTS ON REHEARSAL RATE IN SHORT TERM SERIAL ORDER MEMORY

EXPERIMENTS 7 - 9

The results of the last few experiments (Experiments 3-6) seem to indicate that noise effects on memory occur in conditions either where there is an available opportunity for rehearsal or where maintenance rehearsal is employed as the dominant strategy in order to enhance recall performance.

These results thus suggest that noise reinforces use of a maintenance rehearsal strategy but beg the question of whether use of this strategy is due to a change in the capacity for rehearsal or due to an optional change in the manner in which the incoming information is chosen to be processed. A number of related questions which are more specific to the results obtained with the serial order recall paradigm also need further attention. Firstly as suspected by Wilding and Mohindra (1980) and substantiated by the results of Experiment 3 and 4, the role of articulation when it occurs in the presence of noise needs to be examined. It was shown that articulation improves performance for information presented at a fast rate of presentation ($\frac{1}{2}$ s per item compared to 2s per item) and that in these conditions its effects were in the same direction as those of noise (for example it improved performance on acoustically similar letters to a greater extent than that on dissimilar letters). This effect was replicated in Experiment 4 and leads to the second question - why does noise interact with the phonemic similarity effect? Some previous research has also indicated the occurrence of such an interaction. Using a foreign language text, presented binaurally at 85 dB sensation level, Colle and Welsh (1976) demonstrated that memory performance on phonologically similar items remained stable whereas that on phonologically dissimilar items was reduced. Baddeley (1968, Experiment 4) observed a similar effect on a sequence of auditorily presented three letter words under 70 dBA white noise. 39% of his subjects recalled dissimilar words better in noise whereas 55% recalled similar items better in noise. This latter result was even more surprising given that perception of similar items was impaired in noise, relative to the quiet conditions. Why then should noise or a foreign language text aid the recall of acoustically similar items while articulating aloud impairs the recall of such items (Wilding and Mohindra, 1980, Experiment 2)? To answer this question we need to know what causes the phonemic similarity effect in the first place and in what way does noise help to reduce this effect.

According to Baddeley and Hitch (1974) and Baddeley (1976), the working memory model attributes the phonemic similarity effect to utilization of the articulatory verbal loop. It is also suggested that the loop is responsible for the word length effect where words of short temporal duration are better recalled than longer items (Baddeley, Thomson and Buchanan, 1975). A clue to the process which mediates both the phonemic similarity and the word length effect has been provided in studies by Clifton and Tash (1973) and Chase (1977). These investigators showed that increased acoustic similarity and increased syllable duration slow the rate at which subjects rehearse. Could it then be the case that noise is having a related effect? If it does, how can we explain the results obtained? In effect, if noise slows the rate of rehearsal of individual items, fewer items would reside in the loop at any one time, given the limited temporal capacity of the loop. This would mean that fewer confusions of order could occur and that this gain could sometimes counteract the reduction in the number of items held. This suggestion could therefore explain the improvement obtained by Wilding and Mohindra (1980) in recall performance of acoustically similar items during noise, since it is predicted that the benefits of this reduced interference would be greater when items are phonologically similar. The effect of noise on dissimilar items would be mainly a reduction in the number of items recalled. It should be noted however, that the improvement obtained by Wilding and Mohindra for confusable items was only an improvement relative to performance of these items in the low noise conditions, and that overall performance for confusable items was always poorer than that for the non-confusable items.

The next three experiments were carried out in an attempt to find empirical support for the above propositions. Experiments 7 and 8 attempted to measure the effect of noise on rehearsal rate directly. Two tasks were investigated in the first experiment: reading lists of acoustically similar and dissimilar consonants in noise, and overt rehearsal of these same lists also in noise. The reading condition served as a control so that increases in noise due specifically to the memory component of the second task could be isolated.

Experiment 8 was similar in nature and manipulated syllabic word length as well as acoustic confusability to determine whether effects of noise on rate of rehearsal of words resembled those on consonants. These two experiments supported the prediction that noise would slow rehearsal. Therefore Experiment 9 tested what implications slowing of rehearsal would have on recall performance of lists of words. It could be predicted that slowing of rehearsal would have different effects on recall depending on factors such as item length (c.f. Baddeley, Thomson and Buchannan, 1975) and item confusability. Wilding and Mohindra (1980) have already shown that noise can improve recall of short (i.e.consonant) items especially when these are confusable. However increased discriminability and increased spoken length could produce a situation where slowing of rehearsal impairs recall. Therefore in Experiment 9, ordered recall of words of different spoken length and low acoustic similarity was tested to determine whether noise (by slowing rehearsal) would impair recall of these items.

5.1 EXPERIMENT 7

METHOD

This experiment was designed to measure directly the time taken to articulate sequences of five consonants during reading and rehearsal activity under two levels of continous white noise (65 and 85 dBC) presented binaurally through headphones.

Design and Subjects

12 subjects took part in the experiment, with each experiencing both tasks under each level of noise. They were students and postgraduates from all departments of Bedford College. All subjects attended two sessions on successive days and experienced a different noise level in each session. The order of noise conditions was counterbalanced over sessions and the order of the task (read or rehearse) within sessions was randomised.

Materials

The stimulus material comprised sets of 5 consonants drawn from either the acoustically confusable set B D G T P or from the acoustically non-confusable set H M J R Z. Twenty random sequences were generated with meaningful sequences being replaced. Ten sets, each, with five confusable and five non-confusable sequences were used for each of the four noise x task combinations. The sets of consonants were displayed visually (simultaneously) on the screen of a Commodore "PET" computer.

Procedure

On each trial the sequence of consonants was displayed and the subject was required to overtly read or rehearse it as quickly as possible five times (subjects kept track of the number of repetitions on their fingers). Once the set of consonants was on view subjects were allowed as much time as they wanted to inspect the set before beginning either the timed reading or rehearsal activity. As soon as the subject was ready to begin articulating he/she pressed the 'RETURN' key on the computer keyboard. In the rehearsal trials this action blanked the screen while the subjects rehearsed the set of consonants, but in the reading trials the letters continued to be shown. In each case their overt response was tape recorded for later analysis.

Analysis of responses

Total articulation time was obtained by feeding the subjects recorded response into an analogue to digital converter which sampled at a rate of 60 times a second for the presence or absence of speech. The time from the beginning of the first repetition of the string of consonants to the end of the fifth repetition represents the dependent variable.

RESULTS

Mean articulation times per item under each combination of Noise X Task X Item type were calculated. Means representing the scores for 11 subjects were used for analysis because the results of one subject had to be dropped due to frequent errors and dysfluencies produced by that subject during the rehearsal trials.

A three-way within subjects ANOVA carried out on the articulation times showed a significant main effect of Item type ($F = 10.32$, d.f. 1, 10, $P < 0.01$) due to acoustically confusable items taking longer to articulate than non-confusable items. Two significant interactions involving noise were also found. These were between Noise X Task ($F = 3.28$, d.f. 1, 10, $P = 0.05$) and Noise X Task X Item type ($F = 6.5$, d.f. 1, 10, $P < 0.025$) tested by a one tailed test. As it was predicted that noise would have a greater effect on acoustically confusable items than on non-confusable items (as found by Wilding and Mohindra, 1980) the one tailed test for the direction of the Noise X Task and the Noise X Task X Item type interaction was felt to be justified. The former of these two interactions showed that while the time taken to articulate the consonants in the rehearsal task increased during loud noise, there was no equivalent increase during the reading task. The time taken to read the acoustically confusable items in noise actually decreased whereas that for non-confusable items showed a slight increase. The second interaction is shown in Figure 7.1.

DISCUSSION

If, as seems plausible, the rehearsal task requires an extra stage, a retrieval component which is not present during reading, the interactions obtained point to the noise effects taking place at this stage. It has been suggested that speakers monitor their own response and continously compare the signal produced

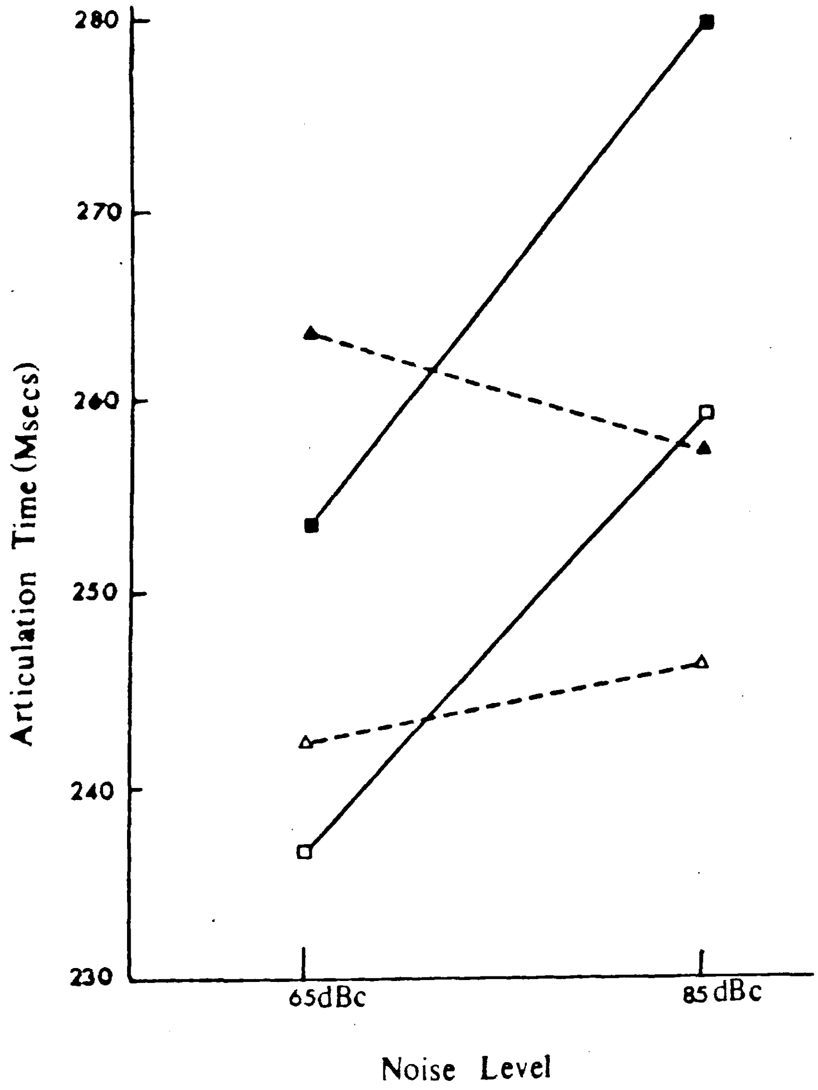

Figure 7.1

Mean articulation time per item (msecs) for the following conditions at each noise level: Non-conf./Read △---△, Conf./Read ▲---▲, Non-conf./Rehearse □—□, Conf./Rehearse ■—■.

to that intended. Such a feedback coupling of acoustic analysis and motor control would provide a basis for correcting articulation if it goes astray and could aid in the organization of sequences of gestures (Barlow and Abbs, 1978).

When rehearsal of a single input is required feedback is also needed to maintain the internal representation of the stimulus. In the reading task the visual stimulus remained present and the rehearsal could be guided by continual reference to the stimulus, but in the rehearsal task the only source for maintaining the internal representation is the feedback from the previous cycle. Since noise only had effects on the rehearsal task, it must be at this stage that noise effects occur, either by affecting the quality of the feedback or the speed of transforming it for use by the articulatory system. It will be noted that the circumstances present in the reading condition in this experiment resemble closely those which existed in experiment 2, where again items were presented simultaneously, but on that occasion for memorizing. Again on that occasion items could be rehearsed by reference to the stimuli on the screen of the computer. No effects of noise were observed on recall under those conditions which further suggests that only when rehearsal has to rely on some internal representation of the to-be-remembered material do noise effects become apparent.

The use of overt rehearsal to measure effects of noise on speed is obviously not ideal for testing what happens in memory tasks where rehearsal is covert. However some attempts to measure speed of covert rehearsal showed that the absence of control over the adequacy of performance rendered this method impractical. Many subjects were seen to be mouthing or sub-articulating but slurring over items and making many errors. It will be noted that errors were checked and rerun when overt articulation was used. Accordingly until some more satisfactory method can be devised to evaluate covert rehearsal, the less satisfactory alternative of using overt rehearsal has been adopted. The absence of any effect on the reading task indicates that it is not dependent simply on overt articulation, but on some internal process.

One point to note however was the lack of a Noise X Confusion interaction. It is possible that because items were presented here simultaneously for as long as the subject required to commit them to memory, strong inter-item associations occurred (c.f. Experiment 2). Therefore the effects observed may not be entirely equivalent to the situation where items are presented successively at a rapid rate. On the other hand this may imply that noise adds approximately a constant increment to the circulation time per item. This is tested again in the next experiment using acoustically confusable and non-confusable words instead of consonants.

5.2 EXPERIMENT 8

METHOD

This experiment though similar in concept to Experiment 7, varied in the type of stimulus material used. Single words, or lists containing combinations of four words were presented, and subjects were required to read or rehearse these words under two levels of white noise (65 dBC or 85 dBC).

Subjects and Design

Ten subjects each performed three tasks: repeating aloud a single word five times, reading aloud a list of four different words three times and rehearsing aloud a list of four different words, also three times. In each case subjects were instructed to articulate as quickly as they could. Each subject attended two separate sessions and experienced 65 dBC noise on one session and 85 dBC noise on the other. The order in which the noise occurred was balanced such that half the subjects had the 65 dBC condition first. Subjects were postgraduates or members of the teaching staff of Bedford College.

Stimulus Materials

Eight sets containing four words each were used (see Table 8.1). These included sets of words used in an experiment by Baddeley et al. (1975), Experiment 3; others were added by the present author. These sets varied according to the number of syllables the words contained - 1 or 2, the length of the words in spoken duration - short or long, and acoustic confusability - high or low. Four lists were derived for each set of four words by randomizing the order of occurrence of the words. One of these lists was used during the reading trials, the other three being used in the rehearsal trials. A single list containing all 32 words, was also produced, with the order of occurrence of words being randomized. In all cases the stimulus material

Table 8.1

Stimulus material used in Experiment 8

	One - syllable		Two - syllables	
	short	long	short	long
Low acoustic similarity	Pin	Crane	Ember	Coerce
	Hot	Yield	Pectin	Humane
	Lap	Worst	Bishop	Cyclone
	Bug	Twice	Pewter	Harpoon
High acoustic similarity	Cad	Bead	Ducking	Declaim
	Cap	Beet	Topping	Detain
	Can	Bean	Tapping	Terrain
	Cab	Beam	Picking	Pertain

was displayed visually on the screen of a Commodore 'PET' computer. Noise was presented to subjects in the same way as in Experiment 7.

Procedure

This resembled as closely as possible the procedure used in Experiment 7. In the case of the 32 word list, a single word was displayed and the subjects were required to repeat the word five times, as quickly as possible. The experimenter monitored the accuracy of the number of repetitions. For the remaining two tasks, lists of four words were displayed (all words appeared simultaneously on the screen), and the subjects were required to read or rehearse them as quickly as possible, three times. To ensure that all responses, during the rehearsal task, were free from order errors or dysfluencies, subjects were allowed to restart the timed rehearsal by pressing a specially labelled key. The list of words then reappeared and the subjects could continue, as if the list had been presented for the first time. For all the tasks the dependent variable was the time taken to carry out the required articulation, and was measured in the same way as described in Experiment 7. In each case subjects overt responses were also tape recorded for further detailed analysis. Here, however, in contrast to Experiment 7 where subjects recorded response was fed into an analogue to digital converter to obtain total articulation time, the time between subject's two key presses indicating the beginning and the end of the articulation period was used. When the data obtained in Experiment 7 were analysed in this way, this simpler measure was found to provide exactly the same pattern of results as the measure obtained by measuring articulation time on tape.

RESULTS

Mean articulation times per item were calculated for each task and for each combination of the noise, number of syllables, spoken length and confusability factors. A four way within-subject ANOVA carried out on the mean articulation times for the single word repetitions showed no significant effects of noise ($F < 1$) nor any significant interaction involving noise. However main effects of number of syllables ($F = 33.79$, d.f. 1,9, $P < 0.001$) and of spoken length ($F = 63.95$, d.f. 1,9, $P < 0.001$) were significant, showing that two syllable words of long spoken length were repeated more slowly than one syllable words and words of short spoken length. The two-way interaction between spoken length and confusability also reached significance (F=18.85, d.f. 1,9, $P < 0.01$) showing that although short spoken length, confusable words were articulated more quickly than their non-confusable counterparts, the opposite was true for the long spoken length confusable items.

The mean articulation times for the two remaining tasks were subjected to a five-way within-subject ANOVA. Main effects of Noise (F=6.59, d.f. 1,9, $P < 0.05$); Task (F= 10.45, d.f. 1,9, $P < 0.01$); Spoken length (F= 62.35, d.f. 1,9, $P < 0.001$); Number of syllables (F= 24.64, d.f. 1,9, $P < 0.01$) and Acoustic confusability (F= 17.0, d.f. 1,9, $P < 0.01$) were all significant. Articulation time was found to be longer in loud noise than quiet, longer during the rehearsal than reading conditions, longer for two syllable than one syllable words, longer for words of long spoken length than words of short spoken length and longer for words of high confusability than for words of low confusability.

Two interactions involving Noise also reached significance: first of these was the interaction of Noise X Task (F= 4.41, d.f. 1,9, $P < 0.05$ on a one tailed test) which showed that noise slowed articulation in the rehearsal task by 41ms per item and in the reading task by only 2.8ms per item. The second interaction involved the factors Noise, Task and Spoken length (F= 8.73, d.f. 1,9, $P < 0.025$). This is shown in Figure 8.1. If we consider just the short spoken length items first the results show that although rehearsal is slower than reading,

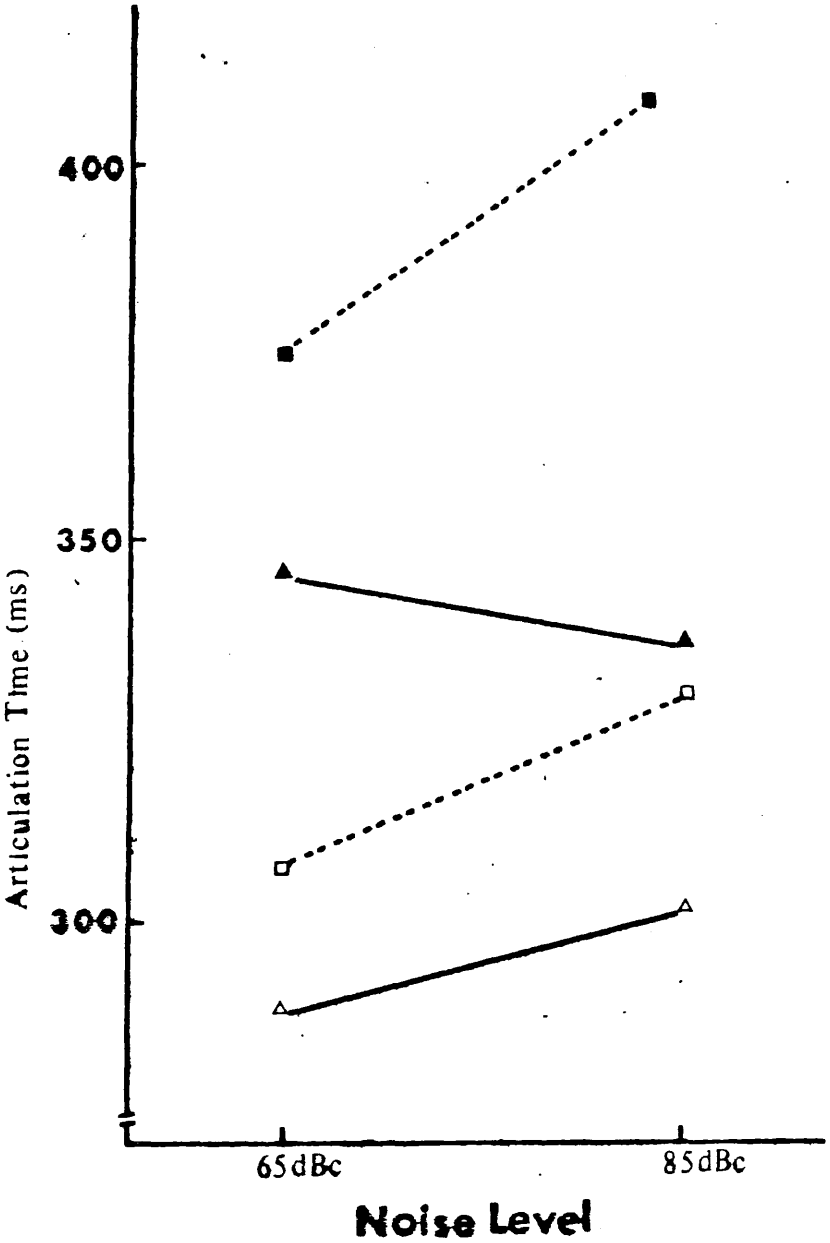

Figure 8.1

Mean articulation time per item (msecs) for the following conditions at each noise level Read/long spoken length ▲——▲ ,Read/short spoken length △——△ , Rehearse/long spoken length ■---■, Rehearse/short spoken length □---□.

noise only has a slight effect on both tasks. For the long items however, the picture is different; noise has a marked impairing effect in the rehearsal conditions and a small improving effect in the reading conditions.

Other significant interactions included the factors Task, Number of syllables, Spoken length and Confusability. Closer examination of the highest order interaction of these factors ($F= 6.67$, d.f. 1, 9, $P < 0.05$) showed that this effect may well have been due to the relatively fast performance of the 2 syllable, short spoken length, confusable items (tapping, topping etc.)in the rehearsal task. This effect would need replicating with other word lists before any weight can be placed on it, therefore it will not be considered further. The main findings therefore are that noise slows performance in the rehearsal task, especially with words of long spoken length. Again no confusability by noise interaction was observed in these data. This therefore confirms the possibility that noise adds a constant increment to the articulation time. In the case of words however, no measure was available of the degree of confusability. This could only be gauged from the difficulty which subjects expressed when learning particular sets of items. The set Declaim, Detain etc. was felt by most subjects to be the most difficult (this was established from the number of restarts the subjects made in the rehearsal trials) closely followed by the set Bead, Bean etc. The Tapping, Topping set created the least number of problems.

In order to discover where the major effects of noise were concentrated, more detailed analysis of the spoken response of three subjects showing the largest impairment on performance in loud noise, was undertaken. This involved analysing responses during the reading and rehearsal trials of 4 word lists, by digitizing their recorded speech on a computer sampling at a rate of 60 times a second for the presence or absence of speech. This method allowed the duration time for each articulated item, as well as the length of the pause between items to be measured.

Table 8.2 shows the mean length per item and mean length of pause between items, for each item in the eight list types in the two noise levels. Analysis of this data showed that in the rehearsal conditions noise consistently slowed the spoken duration of the items. One data point was missing but all the remaining 23 comparisons (3 Ss x 8 comparisons) were in the same direction ($P < 0.001$ by a binomial test, counting the missing point against the prediction). However, noise had no consistent effect on the pause time between items. (On 11/24 occasions, $P > 0.05$, the pause time was larger in noise). The effect of noise on the reading task did not show the same trend. On the duration measure 11/24 points, $P > 0.05$, were larger in noise, and on the pause measure 9/24, $P > 0.05$, pauses were longer in noise.

TABLE 8.2
MEAN DURATION (D) AND PAUSE TIME (P) PER ITEM (MSECS) FOR EACH LIST TYPE, IN ALL CONDITIONS

NO. OF SYL	LENGTH OF SPOKEN DURATION	ACOUSTIC CONFUSA-BILITY	READ				REHEARSE			
			65dBC		85dBC		65dBC		85dBC	
			D	P	D	P	D	P	D	P
1 SYL	SHORT	NC	168	130	188	100	155	144	189	130
		C	201	214	214	196	196	288	225	293
	LONG	NC	201	164	247	121	200	185	263	154
		C	239	223	215	167	239	238	292	298
2 SYL	SHORT	NC	260	142	242	126	222	171	311	156
		C	301	141	329	133	279	215	351	233
	LONG	NC	310	141	351	148	347	203	413	185
		C	355	176	308	188	372	295	432	332

DISCUSSION

The main finding of this experiment was that noise slowed the rate of rehearsal, especially for words of long spoken length, but had no effects when words were required to be read. This supports the findings from the previous experiment, where similar effects were observed using sequences of consonants. This suggests that the effects of noise are concentrated on the rehearsal or retrieval stages of the memory process. In order to distinguish between these possible explanations, detailed analysis of the articulated duration of each item and the pause between items was investigated. Analysis showed that noise affected rehearsal rate by increasing only the duration of each item and not the pause. But there is no apparent way of separating retrieval or search time during utterances, from search time between successive utterances, because items are constantly being retrieved throughout the time taken for responding. In other words subjects could be searching for the next item while articulating the current item. Instead the results conclusively show that the increase in duration of the utterance, during the rehearsal task, cannot be attributed to prevention of the acoustic feedback by noise (a situation analogous to delayed auditory feedback) because no equivalent increase was found in the reading task.

So what has been shown so far is that noise slows the rate of rehearsal. What effects, if any, will this impairment have on memory performance? As has been pointed out before, memory performance for short confusable strings may be improved by noise, because of the reduced inter-item interference. However, if items occupy more time in the articulatory loop than consonant names, slowing down the rate of rehearsal may have the opposite effect of impairing memory performance. The next experiment was carried out to test this proposition. Baddeley, Thomson and Buchanan, (1975) have shown that short term memory span is not constant, but varies with length of the words to be recalled. They demonstrated that if the number of syllables and the number of phonemes are held constant, words of short temporal duration are better recalled than words of long duration as long as the words are presented visually. On the basis of this and the results of the last experiment we can predict that in noise fewer words would be held in a limited temporal capacity store and that the number of words held will depend on the spoken length of the words. Contrary to this prediction, if we follow Hamilton, Hockey and Rejman's (1977) proposition that noise speeds up the rate of throughput of information, we might predict that the word length effect would disappear in noise or that noise should have no effect relative to quiet if both long and short words are equally affected.

5.3 EXPERIMENT 9

METHOD

Design and Subjects

20 subjects were run under each noise condition (65 or 85 dBC) in groups of 10, half of each group experiencing each level of noise. The noise was presented binaurally through headphones. All the subjects who participated were students attending Goldsmiths' College.

Stimulus materials

The two sets of words chosen by Baddeley et al. (1975, Experiment 4) were used. These two sets differed in spoken duration (mean duration of the long words was 0.77s and for the short words was 0.46s) as measured by Baddeley et al., but were equal in number of phonemes and syllables. All words had also been matched for word frequency. From both sets of words five lists of five words each were derived by randomizing the order of occurrence. The ten lists were then presented visually using a slide projector coupled to a digitimer, at a rate of 2s per word. The order in which the lists were presented was also randonized.

Procedure

Before the experiment started the subjects were familiarized with the two sets of words and told to begin recall when the blank slide at the end of each list appeared. They were instructed to write the words they recalled in the order in which the words had been presented on specially prepared cards. Noise was switched on 2s before the presentation of the first word and continued until the appearance of the blank slide. A gap of 30s was left between lists for subject's recall and no noise was presented during this period.

RESULTS AND DISCUSSION

The results consisted of the probability of recalling each word in its correct list position under each combination of noise and word length. A four-way ANOVA incorporating noise and subjects as between-group variables and word length and serial position as within-group variables revealed significant main effects of word length ($F = 5.661$, d.f 1, 38, $P < 0.025$) and serial position ($F = 59.878$, d.f. 4, 160, $P < 0.001$).

However the first order interaction of Noise and Word length did not reach significance. Instead, there was a second-order interaction between Noise, Word length and Serial position ($F = 4.21$, d.f. 4, 152, $P < 0.01$) which is shown in Figure 9.1. This showed that noise mainly affected long words in the early serial positions. An unplanned comparison of the Noise X Word length interaction at serial positions 2 and 3 compared against the other serial positions showed that the source of the interaction arose from the poor recall of long items in these positions, when exposed to noise ($F = 14.03$, d.f. 1,152, $P < 0.01$ on a Scheffe test).

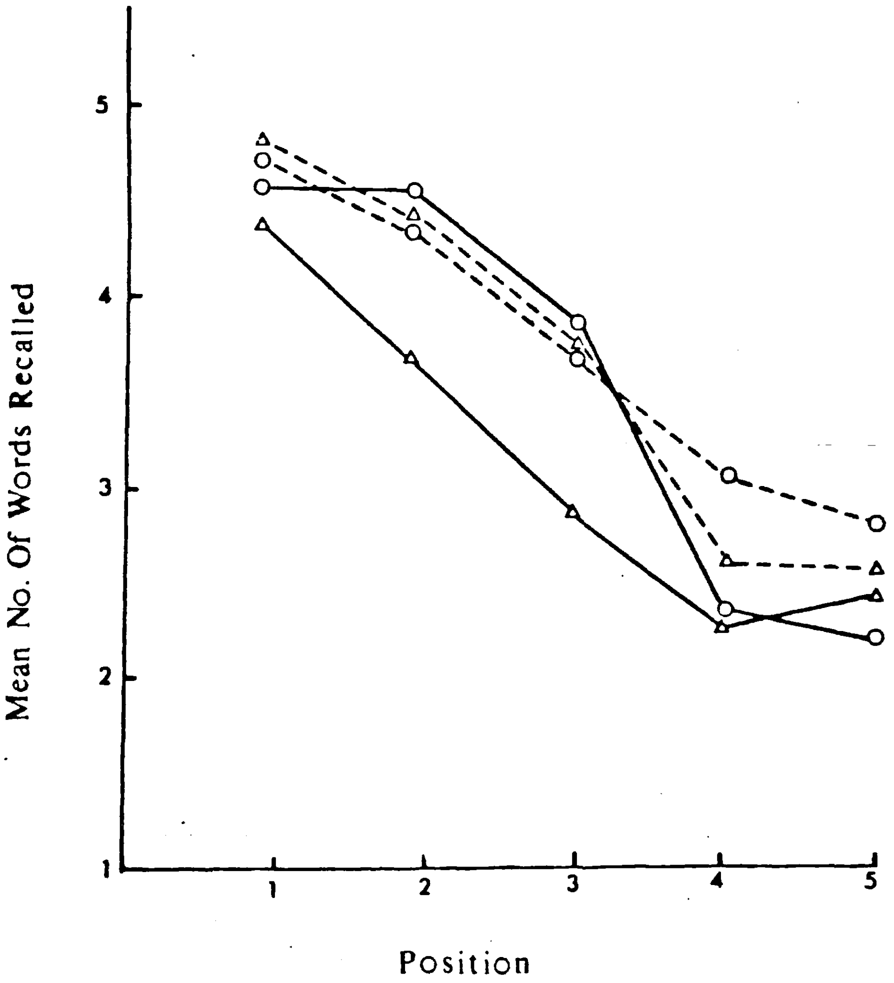

Figure 9.1

Mean number of words recalled at each serial position in the following conditions: 65dBC/short O----O, 65dBC/long Δ----Δ, 85dBC/short O——O, 85dBC/long Δ——Δ.

These results were interpreted as showing that the effects of noise on memory performance depend on the spoken length of the words. As predicted memory performance on longer words was poorer in noise than that on shorter words, especially for long words presented earlier in the list. It is interesting that this decrement does not occur for items presented at the end of the list, as this would indicate that later items had not been attended to. Instead, what seems more plausible is that items in positions 2 and 3 are displaced in the rehearsal cycle by later items because of the temporal limitations on the capacity of the articulatory loop. Consequently these positions represent items which are rehearsed the least number of times.

GENERAL DISCUSSION

Results obtained from Experiments 7 and 8 showed that noise slowed the rate at which items are rehearsed in the articulatory loop. Further, the results of Experiment 9 revealed that slowing of rehearsal had an adverse effect on the serial order recall of words of long spoken length, particularly for those words presented early on in the list. Previously it has been shown that when short spoken length items such as consonants are required to be remembered, noise improved the recall of acoustically confusable letters while slightly impairing that of non-confusable letters. The overall picture which is thus emerging, at least within the confines of the serial order recall paradigm is that noise has the capacity for either improving or impairing memory depending on the type of items that are to be remembered. Wilding(in Mohindra and Wilding, 1983)has proposed a mathematical model which can account for this type of fluctuation and thus can be used to predict what the resultant effect of noise in given conditions would be.

In the model it is assumed that N items are to be placed in the memory system, in the correct sequence, n of which are held in the articulatory loop, and the remainder retrieved from a separate memory source or placed by guessing. Given 2 items in the loop, let p be the probability of their not exchanging position. The probability of an item retaining position given n items in the loop is therefore equal to the probability of an item not interchanging position with any other. This is p^{n-1}. Such interchanges would be due to inability to discriminate between pairs of items due to loss of some features.

The number of items C which are correctly placed is the probability of each item retaining position, given n items in the loop, multiplied by the number of items in the loop, plus a constant for guessing items not in the loop, and for retaining the first item.

Therefore $C = np^{n-1} + k$

Values of C for different combinations of these variables (with k = 2) are given in Figure 9.2. It is assumed that n is affected by item length and the speed of circulation of items in the loop and p by the degree of acoustic confusability. Figure 9.2 shows that reducing the number of items in the loop, by increasing their length or articulation time, can be harmful for non-confusable items and helpful for confusable items and have little effect for items of intermediate confusability.

Slowing of rehearsal can lead to the type of phenomenon observed in noise. This still however leaves unanswered the question of whether this is the only effect of noise so that it will operate only when rehearsal is occurring already, due to task demands or instructions, or whether noise also increases the propensity to engage in maintenance rehearsal whatever the task, as suggested by Wilding and Mohindra (1980). Lewis (1981) has cast some doubt on the second possibility by demonstrating that noise effects occur only when subjects expect recall and not when they expect a recognition test, the difference being that expectation of recall induces a more active rehearsal strategy. In general noise effects appear to be more consistent and beneficial in tasks where active rehearsal is the most appropriate strategy. However given that increased use of sequential associations in recall occurs when information is presented in noise (Hockey and Hamilton, 1970; Hamilton, Hockey and Quinn, 1972; Daee and Wilding, 1977) and improvement has been found in free recall of random

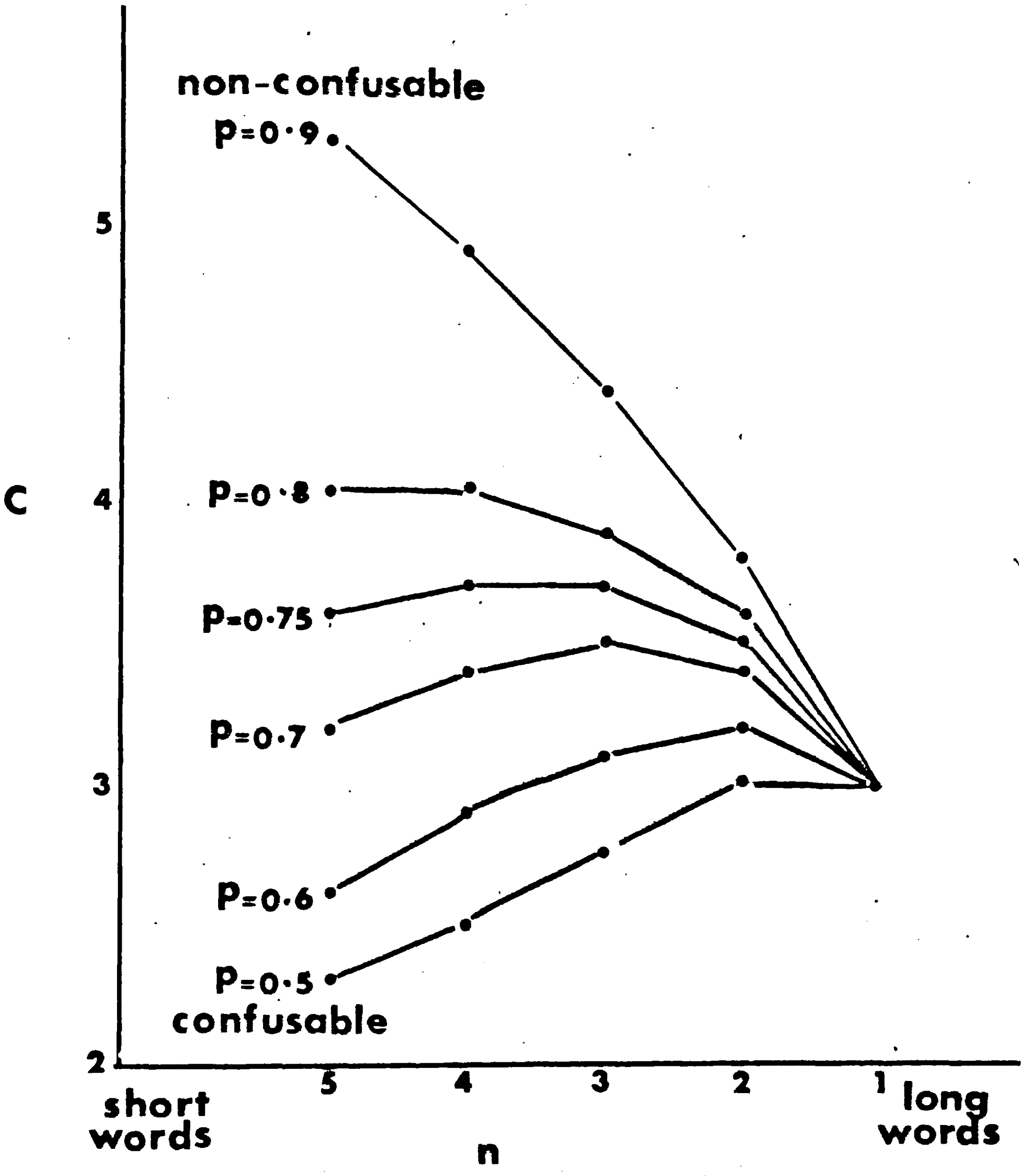

Figure 9.2

Values of C - the number of items correctly placed for different combinations of n (the number of items to be placed) and p (the probability of their not exchanging position) given that the constant k = 2.

word lists which are not acoustically similar when they were presented visually in noise (Lewis, 1981; Wilding, Mohindra and Breen- Lewis, 1982) it seems unlikely that all noise effects can be explained in terms of slowing of rehearsal. Hence it is suggested that noise also encourages the use of maintenance rehearsal and when the basic task already strongly induces such rehearsal, noise effects are due mainly to the slowing of rehearsal and hence vary with task, word length and acoustic similarity of the material, but when the task is less constraining on the strategies adopted, addition of noise will both encourage rehearsal and slow it. A possible reason for the first of these effects will now be considered.

It was pointed out in the introduction that overt articulation and noise did not produce exactly the same results. One difference was that articulation impaired performance on acoustically similar lists while noise improved it. The latter effect has now been explained in terms of slower rehearsal reducing the number of inter-item confusions, while the effect of articulation is assumed to be due to greater reliance on coding which maximizes item similarity. The second difference was that at slow rates of presentation (2s per item relative to ½s per item) articulation impaired recall, especially of acoustically similar items, while noise improved it. Originally Wilding and Mohindra suggested that the difference was due to their having restricted articulation to the current item, thus preventing more adaptable methods, but subsequent unpublished experiments have permitted flexible articulation without eliminating the difference, so another explanation is required. One possibility is that slow rates of presentation make inter-item associations difficult to form, but by slowing the rehearsal rate and prolonging the duration of items noise counteracts this difficulty. Daee and Wilding (1977) made a similar suggestion concerning noise effects.

There still remain some further questions. It is as yet unclear whether noise affects the speed of rehearsal only or of other forms of processing as well. It does slow serial reaction time but only at louder levels than those used here and only late in the work period (Broadbent, 1971), and Goolkasian and Edwards, (1977) reported an increase in the psychological refractory period in noise. However speed of semantic processing is unimpaired (Eysenck and Eysenck, 1979) and if a bias toward semantic processing of word lists is induced by instructions, free recall of structured lists can improve following presentation in noise (Wilding, Mohindra and Breen-Lewis, 1982). Thus it seems unlikely that the preference for maintenance rehearsal which appears to occur in noise can be due to difficulty with more elaborate forms of coding the input.

Instead the preference could be due to an impairment in some component of maintenance rehearsal itself which may lead to its increased predominance. One possibility which has been hinted at previously is that noise impairs access to or retrieval of phonological codes. Since the use of such codes would be required for the process of rehearsal, an impairment in the availability of phonological codes could explain the preference for maintenance rehearsal in the following way.

Tasks which tend to induce maintenance rehearsal, such as serial recall tasks, may have the ongoing operations occupying more of the available processing time. Reduced opportunity for the additional processing required for use of alternative strategies would thus remain. In the free recall situation, particularly where no indication of the length of the list or the categorizable nature of the list is given, subjects may start by using a maintenance rehearsal strategy. This in turn may lead to them becoming locked into the initial maintenance rehearsal strategy and although awareness of list organization might arise as they work their way through the list, by then it might be too late to attempt categorization. Wilding et al.(1982) have reported that the preference for maintenance rehearsal can however be effectively reversed by instructions in a free recall task which encourage use of alternative strategies. Also Breen- Lewis and Wilding (in press) have shown that noise effects are more apparent when rehearsal is induced by instructions. These types of results therefore lend some support to the hypothesis that reduced availability of phonological codes required in rehearsal may indeed be the source of the observed effects of noise. The next experiment thus attempted to measure the time taken to access and use phonological representations in an attempt to find empirical support for the above hypothesis.

CHAPTER 6

EFFECTS OF NOISE ON PHONOLOGICAL MEDIATION

EXPERIMENT 10

One issue currently receiving a great deal of consideration has been whether translation of written material to a phonological representation is a necessary stage in deriving meaning from written material. Two routes to accessing meaning have been postulated: the first of these is a direct route whereby lexical access is achieved from the graphemic representation. Alternatively it has been proposed that phonological mediation (through spelling to sound rules) occurs prior to entry to the lexicon.

As previously discussed, the results of many short term memory experiments suggest that phonemic codes have an advantage over visual codes; thus in memory experiments, at least, some type of phonology may be used simply because memory for those items will be required at some stage. This strategy may also be useful should comprehension of long and complicated sentences be required, since the relatively long lasting traces of auditory memory provide the necessary device to store early parts of the sentence while later material is being read (Kleiman, 1975; Underwood, 1978).

Apart from the evidence from memory studies, evidence from the word identification literature also supports the view that phonological mediation sometimes occurs prior to lexical access. For example, Levy (1978) has presented three types of evidence favouring this view. Firstly it has been shown that in some visual identification tasks, response times increased with increasing number of syllables, even when the number of letters per word were kept constant (Erikson, Pollack and Montague, 1970; Klapp, 1971). This finding was interpreted to indicate that the visual items were being translated to a phonetic form which took longer when more syllables were involved. Second, in a lexical decision task where subjects must decide whether a string of letters is a word or not a word, decision times were slower when the non-words sounded like real words, e.g. BRANE (Rubenstein, Lewis and Rubenstein, 1971; Meyer, Schvaneveldt and Ruddy, 1974). The idea here is that phonological similarity with real words would only influence rejection for non-words if phonemic translation of the graphemic display has occurred. Third, CVC trigrams take longer to classify as non-words than CCC trigrams, perhaps because they are pronounceable and are processed beyond the phonemic stage. Levy (1978), however, points out that although the above mentioned studies indicate that phonemic translation often occurs during visual processing, this does nor necessarily imply that lexical access can only be achieved via speech coding, nor, that it occurs during 'normal' reading.

On this issue Kleiman (1975) is quite emphatic and argues that speech recoding is unnecessary for lexical access but does later qualify this statement by adding that this does not imply that speech recoding is unnecessary for later stages of the reading process. Kleiman showed that college readers can retrieve information about individual words without speech recoding.

In the first of three experiments described by Kleiman (1975), subjects decided whether visually presented pairs of words were either spelled alike after the first letter (e.g. lemon and demon), or whether they were rhymes or whether they were synonyms. It was assumed that in the spelling task the decision was made on the basis of visual information whereas in the rhyming task subjects were forced to recode to speech before deciding. Finally because the third task required information about the meaning of words, it was assumed to be tapping the process of lexical access. Each subject performed the spelling, rhyming and synonym decisions both with and without a concurrent shadowing task. This task consisted of subjects being required to repeat digits that were rapidly presented and was designed to disrupt recoding to speech. It was expected that since the spelling and the synonym judgements did not require recoding, they would not be interfered with by the shadowing. Rhyming,however, would show the greatest interference since it is assumed to require recoding before a response can be made. The results clearly supported these predictions with both the spelling and the synonym tasks showing a small interference effect and the rhyming task showing a large effect. In a further experiment, Kleiman's subjects were required to search five word sentences based on graphemic, phonemic or semantic categories, with and without digit shadowing. Again visual presentation was used in order to show that visual processes could suffice in conditions where phonological processes were suppressed by digit shadowing.

As expected, significant effects of shadowing were observed on the phonemic decision task (for example to decide that a rhyme of CREAM is present in the sentence: He awakened from the dream). However, graphemic and category decisions were relatively unaffected. In addition to the three conditions already mentioned a fourth condition-judging sentence acceptability-was also included. This task required the integration of word information into a larger context and was presumed to include a lexical access stage, a comprehension stage and a storage load stage similar to that needed for normal comprehension of sentences. Examples included semantically acceptable sentences such as "Noisy parties disturb sleeping neighbours" to unacceptable sentences such as "Pizzas have been eating Jerry". The results showed that the effects of digit shadowing on this task were severe, and at least equal to the effect on the phonemic task. Therefore it was implied that phonological coding had occurred not on a word to word basis, but on groups of words and perhaps on the whole sentence.

Based on this pattern of interference, Kleiman concluded that phonological coding was not required for single word recognition, but that should even a short sentence be required to be comprehended then phonological mediation would occur. Levy (1975) and Martin (1978) have also studied the role of phonological recoding in visual word recognition by measuring the amount of interference caused by a concurrent articulatory task. They also arrived at similar conclusions to those of Kleiman, suggesting that concurrent vocalization prevented the formation of a phonological representation for comprehension. However they differed from Kleiman as to the exact function of the phonological code. Levy suggests that phonological mediation was functioning as something other than as an aid to short term storage whereas Martin suggested that phonological coding was the usual path to the lexicon.

However recent critical reviews of this area with respect to the role of phonological coding in reading all raise doubts about the above conclusions, and in particular question those of Kleiman and those of Martin on methodological grounds (for details see reviews by Coltheart, 1980; McCusker, Hillenger and Bias, 1981; Baddeley, Elridge and Lewis, 1981; Besner, Davies and Daniels, 1981). The crucial point which was said to have been ignored by Kleiman was the question regarding the stage at which the phonological representation was used. For example Besner et al. (1981) point out: "as soon as a distinction is made between pre-lexical and post-lexical phonology, it is logically possible that rhyming could be done using prelexical _or_ postlexical phonology. But if it is postlexical phonology that is being used in the rhyme condition of Kleiman's experiments, then the fact that suppression hurts rhyming is entirely irrelevant to the question of whether phonology is being used in the synonym condition since here it is prelexical phonology which is of interest". Besner et al (1981) therefore decided to study for themselves what role phonological coding plays in achieving lexical access. They started off by replicating an experiment reported by Baron (1977) where a selective effect of suppression had been demonstrated in a task which required use of prelexical phonology in comparison to one where prelexical phonology was not possible. Baron had used Roman numerals I through to IV or the English words ONE through to FOUR, and had assumed that the Roman numerals could only be accessed using the visual route to the lexicon, but that the English words could be accessed either visually or by applying grapheme-phoneme conversion rules. When subjects were asked to carry out a comparison task (where both types of items could be presented) while either counting backwards from ten, or silently, the difference between the silent and articulation conditions with English stimuli was significantly greater than the difference between the two Roman conditions. Baron had therefore concluded that subjects were likely to have been using phonological coding at least some of the time in the English condition. According to Besner et al. however, there are at least two problems with Baron's experiment. Firstly it is suggested that "the use of Roman numerals is unfortunate because a physical comparison of size for five of the six possible combinations will yield a response entirely consistent with that of the numerical comparison, as to which is the larger". Such a strategy had been shown to be used in a similar experiment by Besner and Coltheart (1979). The second artifact was supposed to have arisen from having the subjects count backwards from one to ten in a task requiring the numerical comparison of numbers, thus, :"raising the possibility that what is interfering is not the concurrent articulation itself, but the retrieval of information about number". To overcome these problems Besner et al. replaced the Roman numerals with Arabic numbers and the counting backwards by instructing the subjects to repeatedly articulate "Blah". Under these conditions Besner et al. failed to obtain any differential effect of concurrent articulation upon the Arabic or the English script. A replication of Martin's (1978) Stroop colour word matching task, with or without concurrent articulation also failed to show an effect of articulation, on the performance of the task.

Further experiments by Besner et al. examined performance with visually presented words and non-words. Subjects were required to make rhyme judgements (Experiment 3, e.g. Blame - Flame) or homophony judgements (Experiment 4, e.g. ALE - AIL) and latency measures and error scores were taken. An effect of suppression on latency, specific only to the words condition in Experiment 3 was shown; this effect however disappeared in Experiment 4. Error rates on the other hand showed an effect common to both experiments. This pattern of results was interpreted as follows: "Suppression prevents or impairs a phonological segmentation process operating subsequent to the retrieval of whole word phonology (a process that is needed for rhyme judgements but not for homophony). Therefore it is assumed that suppression affects the translation of print into an articulatory, rather than a phonological code. Buffer storage and/or maintenance of phonologically coded information derived from print is affected by suppression; phonological recoding for the purpose of lexical access can be carried out without any interference from suppression".

The main implication of the results of Besner et al's study is that lexical access can be carried out without recourse to phonological mediation. However this conclusion ignores some of the error effects observed by Besner et al, for example in their Experiment 3, as reported above, it had been shown that judgements of whether pairs of words rhymed (at least one of which was irregular and hence required postlexical phonology) were slower and less accurate under suppression, while judgements of pairs of non-words, involving prelexical phonology, were less accurate but not slower. (Baddeley and Lewis, 1981, p. 127, in a footnote report that they could not replicate this result). Besner et al. (Experiments 4, 5 and 6) also found unlike Baddeley and Lewis, a significant increase in errors in judging whether whole words and non words sounded alike, though only under rapid suppression. Baddeley and Lewis found a slight and non-significant adverse effect of suppression on both the speed and the accuracy of judging whether a non-word (e.g. Cayoss) sounded like a real word, a marginally significant increase in errors but not in latency in judging whether a pair of non-words sounded alike (e.g. Kerm and Curm) and again a slight and non-significant error increase in judging whether a word and a non-word (e.g. Ocean and Oshun) sounded alike. The general conclusion appears to be that suppression while not having dramatic effects, does tend to increase errors in tasks requiring the use of pre-or postlexical phonology and may also increase latency in the latter case.

One other effect reported by Baddeley and Lewis(1981) and confirmed again by Baddeley, Elridge and Lewis (1981) was the observation that judgements as to whether sentences were semantically anomalous or correct were shown to be less accurate, but not slower, under conditions of articulatory suppression. Since speed of processing was not influenced by suppression it was concluded that articulatory coding normally provides a parallel and supplementary code which may be particularly useful for monitoring order information.

Given these two effects, firstly that suppression in general does not harm rhyme judgements, but that it does interfere with use of a supplementary code for monitoring order information Baddeley et al, and indeed Besner et al, propose that there probably exist at least two phonological codes. The first of these is probably based on articulation and is used to support short term memory, but is susceptible to the effects of suppression. The other is suggested to be an acoustic code, possibly analagous to an acoustic image, which is sufficiently powerful to allow rhyme judgements, but is not necessary for the comprehension of gist and does not appear to contribute to verbal memory.

What relevance does the preceding discussion on the role of phonological coding in reading have on a discussion of the effects of noise as described earlier in this thesis? At various stages in the discussion of noise effects, parallels have been drawn between the effects of noise and those of suppression. In general it has been concluded that noise effects do not resemble those due to suppression (Millar, 1979, Wilding and Mohindra, 1980) but experiments equivalent to those just described with suppression and rhyme judgement tasks have yet to be done. Further in the light of proposals that two types of phonological codes probably exist (Baddeley et al. 1981, Baddeley and Lewis 1981, Besner et al. 1981), only one of which is affected by suppression it would be interesting to see how, if at all, noise effects fit into this schema.

The next experiment thus examined the effects of noise on a rhyme judgement task, and included a synonym judging task for comparison. The purpose of this experiment was to investigate if noise had a disrupting effect on the process of transferring information from a lexical to a phonological / articulatory representation. As will be remembered Kleiman (1975), using shadowing, had shown that shadowing impaired synonymy and graphemic decisions only slightly, while markedly slowing phonemic decisions. The interpretation of these results was questioned,however, on the grounds that rhyming could be performed using either pre or postlexical phonology. Therefore in the current experiment, the rhyme judgement task contained pairs of items, at least one of which was an irregular word, and which presumably would require postlexical phonology. It was predicted that if noise slowed rhyme judgements relative to synonym judgements this would be because of its effects on the postlexical translation process which is required for the successful completion of the rhyming task, but not for the synonym task.

6.1 EXPERIMENT 10

METHOD

Subjects

36 subjects (19 Male and 17 Female), all students from various departments at Bedford College, participated in the experiment.

Stimulus material

Twelve lists of stimuli were used; half in the rhyming condition and the other half in the synonym condition. Lists used in the rhyming condition were identical to those devised and used by Besner, Davies and Daniels (1981, Experiment 3) for their words condition. Each list consisted of ten pairs of words, of which half the pairs rhymed. Another feature of these lists was that at least one word of each pair was an irregular word. Lists used in the synonyms condition contained words drawn from the synonym norms compiled by Wilding and Mohindra (1981). Only word pairs judged to have a synonym rating of at least 5.75 (maximum rating 7.0) were used. Again half the pairs in the lists were synonyms while the other half were not. No attempt was made to control the regularity of the words in these lists.

Design

Subjects were randomly allocated to either the 65 dBC or the 85 dBC white noise conditions. Each subject performed both tasks, the rhyme judgement and the synonym judgement task, the order of occurrence of the two tasks was counterbalanced across subjects.

Procedure

Subjects were run individually. Noise was delivered through headphones connected to a purpose built noise generator producing broad band frequency white noise. Subjects were informed of the order in which the two tasks were to be performed as well as of the keys to be used to make positive or negative responses before starting the experiment. Assignment of left and right keys to the positive or negative response was random. Subjects were told that a pair of words would appear on the screen of the 'PET' computer and that they had to decide whether the words rhymed or whether they synonyms, depending on the condition. All subjects were also told that responses were to be made as quickly as possible but that they should work at a rate at which they did not make too many errors. In the event of an error occurring they were to ignore it and continue with the next pair. A new word pair appeared on the screen two seconds after the last response had been made. The order of appearance of pairs in the list was randomized by the computer for each subject. Length of time between the onset of a word pair and the subjects response constituted the dependent variable. This was recorded by the computer as were the number of errors made in each condition.

RESULTS

Mean latencies were calculated for the correct responses for each subject, then any response of more than twice

Table 10.1

Mean latencies in seconds and percentage error in Experiment 10.

		Positive Responses		Negative Responses	
		Latency	%Error	Latency	%Error
65 dBC	Synonyms	0.85	4	1.00	2
	Rhymes	1.03	9	1.11	9
85 dBC	Synonyms	0.96	3	1.10	3
	Rhymes	1.21	13	1.30	11

the mean latency was discarded and the mean recalculated. The results are shown in Table 10.1. A split-plot ANOVA with noise as the between-subject variable and task and response as within-subject variables yielded the following effects. Main effects of Noise ($F = 9.19$, d.f. 1,34, $P < 0.01$); Task ($F = 140.637$, d.f. 1,34, $P < 0.001$) and Response ($F = 171.88$, d.f. 1,34, $P < 0.001$) were all significant with performance being slower in loud noise, on the rhyming task and for negative responses. In addition significant interactions between Task and Noise ($F = 6.04$, d.f. 1,34, $P < 0.025$) and between Task and Response ($F = 8.53$, d.f. 1,34, $P < 0.01$) were also obtained. Further analysis of the first of these showed that the effect of noise was significant in the rhyming task by a Scheffe test ($F = 14.52$, d.f. 3, 34, $P < 0.05$) but not in the synonym task ($F = 5.04$).

The error rates in table 10.1 show that errors increased slightly in the rhyme judging task in loud noise, so the increase in latency was not due to subjects behaving more cautiously.

DISCUSSION

The results showed that noise significantly slowed rhyme judgements, but only slightly and non-significantly affected synonym judgements. According to the predictions this suggests that the effects of noise are specific to the postlexical stage of processing, since only the rhyming task necessitates use of the conversion from a lexical entry to an articulatory response. It is assumed that judgements for the synonym task can be carried out at the lexicon.

However results of an experiment later carried out by Wilding and reported in Wilding and Mohindra (1982) have suggested that the above conclusions need to be reconsidered. One reason why there may be some doubt over the above conclusions is that there was no guarantee that the effect observed above is restricted to the postlexical stage as assumed before. It will be recalled that in the rhyming condition, although at least one of the pair of words was irregular, most pairs included a regular word, usually the right hand member presented on the screen (following Besner et al's order). Also several words were included twice on the list and even one pair was repeated (unfortunately this was not noticed until after the experiment). The effects of this on the strategy adopted are not clear. Also it could be possible that the small increase observed in the latency measure for the synonym task could be due to use of a prelexical phonological route as a carry over strategy.

Hence in the experiment reported by Wilding and

Mohindra (1982, see Appendix 1 for details) better control of the processes being studied was ensured, such that access to postlexical phonology only, was studied in one condition and prelexical in another. Because it proved impossible to devise enough rhyming pairs in which both items were irregularly spelled, words were presented successively and the time taken to make the judgement following the presentation of the second word only was measured. Three tasks were employed:

(a) a visual matching task without noise to obtain a baseline latency for each subject; here words were to be matched on the last three letters and all pairs rhymed.

(b) a rhyme judgement task in which the second word presented was irregular and required use of postlexical phonology.

(c) a rhyme judgement task in which the second item presented was a non-word which thus required use of prelexical phonology to match it to the preceding word.

Results showed that 85 dBC noise affected the third task only, suggesting that the results of Experiment 10 may have depended on subjects using prelexical phonology in some cases. Error rates were not affected by noise.

In the light of the result obtained by Wilding and Mohindra, the decision about whether the precise effects of noise are pre or postlexical becomes rather difficult. Some reservations have already been put forward about the stimuli used in Experiment 10; moreover since a non-word condition was not included in that experiment this further adds to doubts about noise effects being located postlexically . What is clear is that noise does indeed affect access to a phonological representation, be it at a pre or a postlexical stage. In this respect its effects are clearly different from those of articulatory suppression discussed earlier, where suppression was shown to increase errors but not latency in tasks requiring prelexical phonology. This therefore confirms previous conclusions based on different evidence (Millar, 1979; Wilding and Mohindra, 1980) that the effects of noise do not resemble those of suppression.

CHAPTER 7

CONCLUSIONS AND SOME SPECULATIONS

The experiments described in this thesis have confirmed the results of previous studies of the effects of white noise on memory while attempting at the same time to investigate the cause of these effects. What emerges from these experiments is that the effects of noise, at least at the levels of noise used here (between 65 and 85 dBC) are subtle and may be specific to not only the memory tasks used but also to the stimulus material used in the presentation of these tasks.

The main finding to emerge from the results of the first few experiments was that loud noise improved serial order recall of acoustically similar items where the stimuli were presented successively, but had no effect where the stimuli were presented simultaneously. This suggested that the effects of noise are likely to be observed in presentation conditions which impose restrictions on the time available for rehearsing items and also where rehearsal depends on some internal stored representation of the items rather than being guided by the visual availability of the items. This suggestion was later confirmed in Experiment 7 where it was shown that noise significantly slowed the time taken to rehearse items held in some internal memory store but had no effects in conditions where the items to be rehearsed were visually available to the subject.

As pointed out in Chapter 2, rehearsal in serial order recall tasks is probably mediated through phonological coding of the items since this method is purported to be especially useful for the retention of order information. Assuming that such a phonological representation is being used, the results of Experiment 1 and 2 suggest that difficulties in availability of the phonological representation may possibly account for the results obtained.

The question of the amount of time available for retrieval of a phonological representation and for rehearsal was further explored in Experiments 3 and 4. Very fast rates of stimulus presentation were used in order to prevent phonological coding or rehearsal occurring during the presentation of items. However opportunity for retrieval of a phonological representation and for rehearsal was provided in some cases in a delay period following presentation of the items. It was shown that although the fast rate of presentation almost completely eliminated the phonemic similarity effect, loud noise improved recall performance of items followed by the delay interval, particularly for items presented late in the list. In addition the results of Experiment 4 showed that at a slow rate of presentation ($\frac{1}{2}$s per item) recall of acoustically similar letters improved relative to that of dissimilar letters particularly if subjects were engaging in overt articulation at the time of presentation of items. This result was interpreted as lending further support to the notion that noise had some effects at the phonological stage of processing and rehearsal since presumably both these stages are likely to rely on some type of articulatory code.

Leaving aside serial order recall for the moment the next two experiments looked at the effects of noise in a recognition and a free recall task. Research on the effects of noise on memory using the free recall paradigm (as reviewed in Chapter 1) had also indicated a preference by subjects for engaging in maintenance rehearsal, thus promoting the tendency for items to be recalled in the order of presentation. One consequence of this in a free recall task where items could be recalled according to semantic category, is that the level of semantic organization used by subjects in noise is reduced. This phenomenon has sometimes been interpreted to indicate that impairment of semantic processing in noise perhaps underlies the choice of a maintenance rehearsal strategy. However recent studies have indicated that this is not a necessary consequence of noise exposure.

Firstly it has been shown that use of a maintenance rehearsal strategy may be specific to the tasks subjects are required to perform. For example Lewis (1981) showed that subjects expecting a recall test perform differently from subjects expecting a recognition test and that only in the former case is memory performance affected by noise. Although a direct test of this hypothesis was not made, the results of Experiment 6 lend some support to the above conclusions. Experiments showed that subjects exposed to 85 dBC white noise and led to expect a recall test did have a tendency to recall more items in the correct sequence than those subjects exposed to 65 dBC white noise. However performance on a recognition test, given unexpectedly after the recall test showed that loud noise had no significant effects on the number of items recognised in comparison to the quiet noise conditions. When recognition was expected (Experiment 5) noise again had no significant effects on the number of items recognised. Also in neither case were any effects of noise observed on the number of false alarms made from among semantically or phonemically related distractors. This last result was particularly interesting since it has been suggested in the past that noise perhaps biases the use of strategies based on physical properties of items and away from semantic strategies. Certainly no evidence for this was found within the recognition memory paradigm.

Secondly, evidence is available to show that preference for maintenance rehearsal can be counteracted by giving subjects appropriate instructions about how to process the items more beneficially. For example Wilding, Mohindra and Breen-Lewis (1982) forced subjects to use a semantic processing strategy by use of a semantic orienting task. In these conditions it was shown that noise,let alone impairing recall of items in categories, actually increased it slightly. However when no semantic orienting task was used, noise slightly impaired performance and use of category clustering.

The third piece of evidence in relation to the preferred use of maintenance rehearsal in noise is concerned with whether apparent difficulties in semantic processing encounterd in noise are due to difficulties either in the encoding of semantic features of individual items or of establishing semantic relations between items. Direct tests of semantic processing in noise reveal no impairment (Eysenck and Eysenck, 1979; Wilding and Mohindra, 1982). In addition Wilding and Mohindra (1982, Experiment 2 and 3) investigated semantic priming in a lexical decision task. Associative priming is observed in a lexical decision task (decide if this letter string is a word or not) when related items precede the target on which the decision has to be made. Hence a quicker decision is made that "doctor" is a word when it is preceded by "nurse" then when it is preceeded by an unrelated word. In Experiment 2, Wilding and Mohindra presented words in pairs, with the decision required only in the case of the second,which might be a word or a non-word; closeness of associations and inter-item delay were both varied. Though the expected priming effect from associated items occurred, neither closeness of the association, nor delay, nor noise affected this. In Experiment 3, a series of words and non-words was used, each requiring a decision. Again a priming effect occurred but it was not affected by noise. Thus no evidence was found for noise affecting semantic processes.

The above results therefore seem to suggest that preference for maintenance rehearsal is not due to the impairment of semantic processing but that subjects may choose this strategy in response to an awareness of the demands placed upon them by the requirements of the task and by the need to overcome any perceived future loss in performance. In other words it could be said that subjects invest extra effort to counteract perceived disruptions caused by noise and that this takes the form of maintenance rehearsal in tasks that are seen as likely to benefit from such investment, whereas in other tasks there may be no obvious way of investing extra effort or of measuring its effects.

Alternatively the use of maintenance rehearsal as a response to noise could be seen as a reversion to a simpler, rather primitive strategy under stress and as such could be considered as another example of the finding that noise reduces flexibility or narrows the range of possible cues or strategies, similar to the effects observed in some perceptual motor tasks such as those demonstrated by Hockey (1970).

One other alternative not considered hitherto, is that noise reinforces or otherwise affects the rehearsal process itself, which thus leads to its promotion. Therefore instead of preference for maintenance rehearsal being due to a failure in semantic processing it may be the result of a change in the overall processing capacity available to the system in noise. Experiments 7 and 8 pursued the capacity question and showed that if subjects were required to rehearse items overtly in noise, in comparison to reading them aloud repeatedly in noise, then rehearsal was slowed whereas reading was not. This effect was shown to occur both for consonant letters and for words with rehearsal being impaired most for acoustically confusable consonants and words of long spoken duration. Experiment 9 then showed that slowing of rehearsal had different consequences for memory performance depending on the particular stimuli in use. Whereas previously it had been shown that loud noise improved memory for strings of acoustically confusable letters, the results of Experiment 9 showed that the type of effect noise had on memory depended on the spoken length of the to-be-remembered items. Thus memory for words of long spoken length was poorer in noise than of shorter words and particularly poor for long items presented earlier in the list. These effects were similar to those observed by Baddeley, Thomson and Buchanan (1975) and indicate that perhaps noise interferes with operations normally requiring the use of the articulatory loop.

It was argued that the consequences of the slowing in the rate at which items are circulated in the articulatory loop during rehearsal will depend on other aspects of the task and a simple model was devised for the sequence recall task used by Wilding and Mohindra (1980). In this model the rate of circulation (and hence the number of items held in the loop) varied, as did the probability of items in the loop being confused with each other due to their acoustic similarity, causing them to exchange position in the list. With this model it was possible to demonstrate that slowing of rehearsal of acoustically similar items would be beneficial because the reduced possibilities of confusion outweighed the loss in the number of items held, while the same slowing could impair recall of a sequence of acoustically dissimilar items. For items of intermediate acoustic similarity, slowing the rate of rehearsal improved sequence recall for short spoken length words, but impaired it for longer spoken length items. Thus the greater benefits of noise in the recall of acoustically similar items noted by Wilding and Mohindra (1980) and replicated in Experiments 1, 3 and 4 in this thesis was explicable. Also the beneficial effects of noise at slow presentation rates observed in the above mentioned experiments, which contrasted with the effects of articulating aloud could be explained if the slower rehearsal in noise is compatible with the longer inter-item interval.

These results suggest, however, that in the majority of memory tasks, adopting maintenance rehearsal may be maladaptive, and they offer no reason for the preference which subjects have for adopting this strategy in noise. However they may indicate why associative links are apparently impaired in noise if it is assumed that items pass through the articulatory loop even in the free recall situation. This assumption is quite likely to hold true when subjects have not been given any indication of the length or the categorizable nature of the list, thus making them at least start by using a maintenance rehearsal strategy. A consequence of the slower rehearsal and the reduced number of items in the articulatory loop at any one time would mean that these conditions, though facilitating strong connections between consecutive items and promoting recall in the correct order, would impair the formation of any within-category associations, since different exemplars from the same category (being randomly distributed in the list) would be unlikely to be held in the loop together. Awareness of list organization by category may arise in time as the subject works through the list but by now it may be too late to attempt categorization as the other strategy predominates. However subjects given instructions preceding list presentation, emphasizing the categorizable nature of the list, may not fall into the maintenance rehearsal trap and will thus have available the option of a higher level processing strategy. In conclusion then, three possible general explanations (which are not incompatible) for the preference of maintenance rehearsal have been explored:

(i) That it represents a regression to a more primitive memory strategy which can be counteracted by making an alternative strategy dominant through instructions or task demands, or the investment of greater effort under stress.

(ii) That it is due to a slowing of rehearsal rate which reduces the transmission of information through associative links which may preclude the option of utilizing operations normally involved in the organization and retrieval of information.

(iii) A possibility yet to be considered in detail, that slowing in noise is restricted to operations involving the retrieval of speech related codes such as provided by an acoustic or an articulatory (or phonological) representation.

Of the above, the third possibility emerges out of a need to consider an explanation for rate of rehearsal being slower in noise. The results of Experiments 7 and 8 showed that rate of overt rehearsal for items visually available during rehearsal was not affected under noise exposure, but that if items had to be retrieved from memory for rehearsal then noise slowed rehearsal.

This suggested that noise in some way interferes with the retrieval process, either by slowing the process itself or because the form in which the information is represented is not up to the usual standard. So far it has been assumed that items held in immediate memory are coded using a speech based phonological code. The results of experiments 3 and 4 suggested that perhaps the availability of phonological codes was impaired by noise. Investigation into the nature of these codes has recently taken place within the context of the reading literature where it has been suggested that two types of phonology exist. The first of these is known as prelexical phonology which, as the name suggests is used prior to access to the lexicon, for example to blend together the sounds from a string of letters (mainly used with non-words or new words). Postlexical phonology, on the other hand, is used after lexical access and is presumably mainly used for the naming of letters or words. Given this distinction between pre and postlexical phonology the assumption generally made in the case of immediate memory (see discussion in Chapter 2) is that the process of rehearsal predominantly relies on the use of a postlexical phonological trace. It has also been suggested by some researchers that reading and comprehension of textual material may also make use of postlexical phonology which presumably provides the necessary memory for holding the individual words while the gist of the sentence is being pieced together.

The last experiment reported in this thesis investigated directly the effects of noise on retrieval of postlexical phonology.

The purpose of this experiment was to investigate if noise disrupted the process whereby information is transferred from a lexical to a phonological representation; for this subjects were required to perform a rhyme judgement task on a pair of visually presented items, one of which at least was an irregular word (thus presumably requiring the use of postlexical phonology for prononciation), in comparison to a synonym judgement task. The results showed that noise significantly slowed rhyme judgements but had only slight and non-significant effects on synonym judgements, thus confirming the prediction that noise effects were specific to the postlexical stage of processing. However the results of a later experiment by Wilding (Wilding and Mohindra, 1982) have cast some doubts upon the above conclusions, for in an experiment exercising tighter control over the processes presumed to be operating, it was shown that noise specifically affected retrieval of prelexical phonology and had no effect on postlexical phonology. Wilding has suggested some doubts about the stimuli used in Experiment 10 and has pointed out that one vital control condition, namely inclusion of a list of non words in the rhyming task was missing.

In a final discussion of their results Wilding and Mohindra (1982) point out that the effects of noise observed in the rhyming task (as reported in the appendix) are clearly different from those observed by Besner et al (1981, Experiment 3) using articulatory suppression instead of noise. Besner et al had shown that articulatory suppression affected both accuracy and speed of postlexical rhyme judgements but only affected the accuracy of prelexical phonological judgements. In an attempt to rationalize the different effects of noise and suppression Wilding and Mohindra present a model which suggests that noise and suppression affect separate components of the processing system. Two assumptions were made to make it possible for the model to explain the (see Fig 10.1) observed effects. Firstly it was assumed that rhyme judgements can be based on matching either articulatory or phonological codes and secondly it is proposed that there is a direct link from the lexicon to the articulatory codes but not from the lexicon to phonological codes. The latter were assumed to be accessed either from print, speech or articulatory codes. Although there is no direct evidence for making these assumptions, equally there is no clear evidence against them. It was further assumed that suppression interferes with articulatory codes by occupying the buffer which holds them, and that noise interferes with access to phonological codes. The observed findings are then explained as follows:

(a) Suppression interferes directly with postlexical rhyme judgements by corrupting the articulatory codes on which these are based, but it interferes only indirectly with prelexical rhyme judgements by input to the phonological buffer from the articulatory buffer or from acoustic feedback.

(b) Noise slows access to the phonological buffer and this interferes with prelexical rhyme judgements, but leaves postlexical rhyme judgements unscathed because the articulatory buffer is unaffected

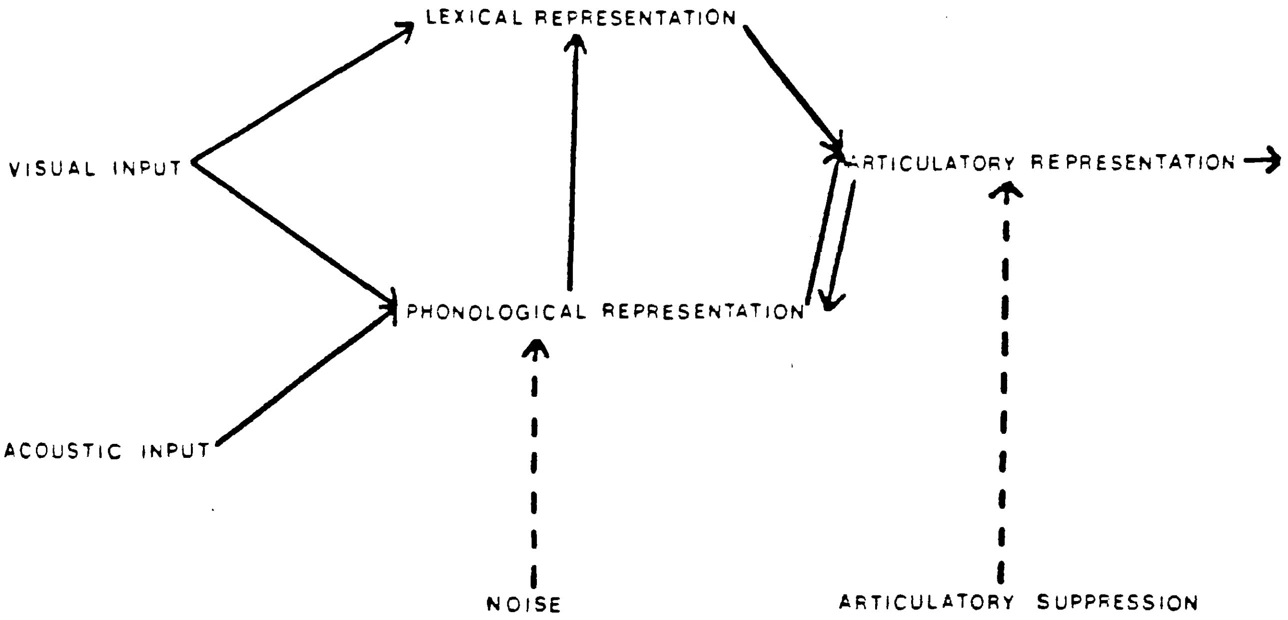

Figure 10.1
Hypothesised flow of information to explain the results of experiments on the effects of noise and articulatory suppression.

(except possibly from some input from the phonological buffer).

(c) The reading task in Experiment 7 and 8, it is assumed could use the lexical route, especially as subjects were allowed to inspect the words for as long as they wished. The rehearsal task, however, required the use of the articulatory loop which cycles information repeatedly between the articulatory and phonological buffers. This cycling is slowed by the impaired access to the phonological buffer in noise, yielding the effects on memory discussed earlier.

It will be noted that in the above model a distinction is made between a phonological representation and an articulatory representation. Recent expositions by Baddeley et al (1981) and by Besner et al (1981) also suggest the existence of two separate phonological codes. Although no clear description of these codes is available the proposal is that the articulatory code can be prevented by articulatory suppression, while the second code, which is described as a type of auditory image, is not affected by suppression. However since the effects of noise differ from those of suppression it is likely that noise specifically affects the second, i. e. the phonological type of code.

Similar distinctions between articulatory and acoustic codes have been made in the past (Wickelgren, 1979) and have also been referred to within the context of noise effects on memory (Poulton, 1977; Broadbent, 1978; Poulton, 1979, Hartley, 1981). Unfortunately no direct tests distinguishing the two representations have been made and recent attempts using noise, unattended speech and suppression are thus encouraging. However the way in which the two codes interact have yet to be clarified and more research is needed in this area. Meanwhile it is suggested that maintenance rehearsal involves cycling between articulatory and phonological representations and as such is sensitive to noise.

The final conclusion therefore is that although noise has traditionally been regared as a means of inducing arousal, the effects observed and outlined in this thesis suggest that, at least for the range of noise (65 to 85 dBC) and for the types of tasks used here, that an explanation of its effects in terms of arousal are unwarranted. Instead the evidence points to noise impairing effective use of phonological codes which causes subjects to change the strategies they normally employ to process visual information for the purpose of remembering. These changes in strategy thus underlie the observed effects on memory performance. However, this does not mean to imply that all effects of noise on human performance can be accounted for in this way. Perhaps at higher levels of noise, other effects due to its arousing, distracting and fatiguing properties also occur, but no attempt has been made to explain these effects within the context of the research reported here.

Explanations of other discrepant findings discussed in the introduction, for example the supposed improvement in long term memory of material learned in high arousal conditions, still remain unclear. But Hockey's (1977) proposal that almost every study finding the above result relied on episodic memory and its implication that high arousal leads to better episodic memory, because of stronger ordering and literal storage of information, seems more than plausible with noise, at least, as it has already been shown that noise promotes maintenance rehearsal and improves recall in the original order.

APPENDIX

APPENDIX 1

Extract from Wilding and Mohindra (1982):

Experiment V

METHOD

The improvement took the form of presenting one word, followed by another which had to be matched with it, so only the time to encode the second word and match it to the first was measured. Three tasks were employed:

(a) a visual matching task without noise to obtain a baseline latency for each subject and provide a practice run. Words had to be matched on the last three letters: in fact all of them rhymed also.

(b) a rhyme judgement task in which the second word presented required access to postlexical phonology.

(c) a rhyme judgement task in which a word was followed by a nonsense syllable which required use of regular pronunciation rules to match it to the preceding word. It was hoped that this task would tap use of the prelexical route to phonology.

Materials.

(a) Matching pairs were words with at least the last three letters identical and which also rhymed (PAIL SAIL) and non-matching pairs were formed from a similar word and a word differing in all the last three letters (SNAIL FOOT).

(b) Rhyming pairs were a word followed by a word rhyming with the first but with the ending spelled differently and in such a way that some other words with the same ending are pronounced differently (SLATE FREIGHT or FOE SEW). Non-rhyming pairs consisted of a word pronounced in the same way as the first word of the matched rhyming pair and a word spelled like the second word of the matched rhyming pair but pronounced differently (CRATE HEIGHT or HOE FEW).

(c) Rhyming pairs consisted of a word ending in a sound which can be spelled in several ways, followed by a nonsense word which could be unambigously pronounced to rhyme with the preceding word, but which was spelled differently (BEAN DENE or DEAF TREAPH). Non-rhyming pairs simply had the first word similar to that in the rhyming pair and the nonsense word could be unambigously pronounced not to rhyme with the preceding word (MEAN SINE or CHEF DAPH).

Fifty pairs of words were used in each condition, ten as practice and twenty each of matching and non-matching pairs in each condition.

Subjects.

Forty subjects were used, males and females from several sources. Some were students attending a summer course in London, some were students at Bedford College and some were residents at a hostel for single people in London.

Procedure

Subjects were randomly assigned to 65 or 85 dB (C) noise which was presented continously throughout the run of fifty trials.

The experiment was again run on a PET microprocessor. All subjects first received condition (a) without noise then conditions (b) and (c) in a randomized order, both at the same level of noise. Order of items was randomized separately for each subject in each condition. The first word was presented for 0.5s and the second followed immediately 2cm to the right and remained until a response occurred. After the response there was a delay of 1.6s until the next trial. Subjects were instructed as follows:

"In this experiment you have to do three variations of the same task. You will be presented with one word on the screen and when it vanishes a second word will appear immediately beside it. Your task is to judge whether the two words are the same in some way which will be indicated and to press one key if they are and another if they are not. Please make your decisions as quickly as possible but keep errors to a minimum. The first task is to decide whether the two words are visually the same in their endings (at least the last three letters, as in PAIL and SNAIL). These words do in fact also rhyme but you can do the task most rapidly by just looking for visual matching. I will ask you to wear the headphones but no noise will be delivered through them during this part of the experiment.

The other two tasks will be given in either possible order, but the computer will inform you before each one which task you are about to get. During both these tasks a hissing noise will be given through the headphones.

Rhyming words.

In this task the first word is followed by a second one which may rhyme with it but look very different. A rhyming pair woud be TRUE and THROUGH and a non-rhyming pair TRUE and THOUGH. You cannot use visual similarity in this task to make your decision.

Rhyming word and nonsense word.

In this task the first word is followed by a nonsense word which may rhyme with it when pronounced in the most natural way according to English pronunciation, but again look very different. A rhyming pair would be HOLE and CHOAL and a non-rhyming pair HOLE and TULE.

After the first task the computer will announce which of the other two is to come next and leave you an opportunity to look at these instructions again if you wish before you start the second task. There is a similar pause before the third task. I will show you the "Yes" and "No" keys and these will stay the same throughout the experiment."

RESULTS

Table V. Mean latencies in seconds and percentage error in Exp. V.

	Noise level					
	65 dBC			85 dBC		
Response	Yes	No	%Error	Yes	No	% Error
Visual match (no noise)	0.84	0.83	2	0.77	0.80	5
Rhyme word-word	1.03	1.16	11	1.01	1.15	14
Rhyme word-nonword	1.05	1.15	13	1.16	1.22	16

Mean latencies were calculated for each subject for the correct responses after responses shorter than 0.2s had been dropped, then any response more than 1s slower than the mean latency was also dropped and the mean recalculated. The results are shown in Table V. Analysis of variance on the results for conditions (b) and (c) showed significant effects of Task ($F = 4.92$, d.f. 1, 38, $P < 0.05$); Response ($F = 24.0$, d.f. 1, 38, $P < 0.001$) and Task X Noise ($F = 4.25$, d.f. 1, 38, $P < 0.05$). The Noise effect was not significant ($F > 1$). Percentage increases in latency from condition (a) were also calculated and the data for conditions (b) and (c) reanalysed. The Task and Response effects were again significant, the Noise effect was significant by a one-tailed test ($F = 3.26$, d.f. 1, 38, $P < 0.05$), but the Task X Noise interaction failed to reach significance ($F = 3.16$). However separate analysis of the two conditions showed that the Noise effect was not significant in condition (b) ($F > 1$) but was significant in condition (c) ($F = 4.35$, d.f. 1,38, $P < 0.05$). Thus it seems reasonable to conclude that noise affected access to prelexical but not postlexical phonology. The error rate was somewhat higher in the 85 than in the 65 dB(C) condition, but the increase in error rate from condition (a) was exactly the same in both noise groups. This suggests that the 85 dB(C) group adopted a more lenient criterion throughout the experiment, responding with faster latencies, as indicated in the matched condition (a), and committed more errors. Hence the longer latencies of this group in condition (c) cannot be explained as due to a more cautious criterion and in fact the differences between the noise groups in this condition is probably somewhat underestimated in this experiment.

APPENDIX 2

Analysis of variance summary tables

```
***** ANALYSIS OF VARIANCE ***** EXPERIMENT 1

SOURCE OF VARIATION                  OF          SS      SS:          MS         VR

SUBJ STRATUM
  NOISE                               1     2.04811     0.33     2.04811      0.588
  RESIDUAL                           18    62.75034    10.02     3.48613     42.386
TOTAL                                19    64.79845    10.35     3.41044     41.466

SUBJ.DISIMSIM STRATUM
  DISIMSIM                            1     7.49817     1.20     7.49817     30.942
  DISIMSIM.NOISE                      1     0.92036     0.15     0.92036      3.798
  RESIDUAL                           18     4.36201     0.70     0.24233      2.946
TOTAL                                20    12.78054     2.04     0.63903      7.770

SUBJ.REPET STRATUM
  REPET                               1     4.26120     0.68     4.26120     27.949
  REPET.NOISE                         1     0.29438     0.05     0.29438      1.931
  RESIDUAL                           18     2.74436     0.44     0.15246      1.854
TOTAL                                20     7.29995     1.17     0.36500      4.438

SUBJ.LAG STRATUM
  LAG                                 1     3.89553     0.62     3.89553     32.688
  LAG.NOISE                           1     0.00161     0.00     0.00161      0.014
  RESIDUAL                           18     2.14511     0.34     0.11917      1.449
TOTAL                                20     6.04225     0.96     0.30211      3.673

SUBJ.CONTEXT STRATUM
  CONTEXT                             1     0.60961     0.10     0.60961      1.920
  CONTEXT.NOISE                       1     0.60178     0.10     0.60178      1.895
  RESIDUAL                           18     5.71638     0.91     0.31758      3.861
TOTAL                                20     6.92778     1.11     0.34639      4.212

SUBJ.POSITION STRATUM
  POSITION                            6   138.66311    22.14    23.11052     73.121
  POSITION.NOISE                      6     4.61846     0.74     0.76974      2.435
  RESIDUAL                          108    34.13433     5.45     0.31606      3.843
TOTAL                               120   177.41591    28.33     1.47847     17.976

SUBJ.DISIMSIM.REPET STRATUM
  DISIMSIM.REPET                      1     1.37476     0.22     1.37476      5.586
  DISIMSIM.REPET.NOISE                1     0.19678     0.03     0.19678      0.800
  RESIDUAL                           18     4.43003     0.71     0.24611      2.992
TOTAL                                20     6.00157     0.96     0.30008      3.649

SUBJ.DISIMSIM.LAG STRATUM
  DISIMSIM.LAG                        1     0.02713     0.00     0.02713      0.087
  DISIMSIM.LAG.NOISE                  1     0.00628     0.00     0.00628      0.020
  RESIDUAL                           18     5.64200     0.90     0.31344      3.811
TOTAL                                20     5.67540     0.91     0.28377      3.450

SUBJ.REPET.LAG STRATUM
  REPET.LAG                           1     2.18706     0.35     2.18706     10.066
  REPET.LAG.NOISE                     1     0.17127     0.03     0.17127      0.788
  RESIDUAL                           18     3.91103     0.62     0.21728      2.642
TOTAL                                20     6.26937     1.00     0.31347      3.811

SUBJ.DISIMSIM.CONTEXT STRATUM
  DISIMSIM.CONTEXT                    1    22.56731     3.60    22.56731     55.861
  DISIMSIM.CONTEXT.NOISE              1     4.93961     0.79     4.93961     12.227
  RESIDUAL                           18     7.27189     1.16     0.40399      4.912
TOTAL                                20    34.77881     5.55     1.73894     21.143

SUBJ.REPET.CONTEXT STRATUM
  REPET.CONTEXT                       1     1.94187     0.31     1.94187     14.259
  REPET.CONTEXT.NOISE                 1     0.00239     0.00     0.00239      0.018
  RESIDUAL                           18     2.45128     0.39     0.13618      1.656
TOTAL                                20     4.39554     0.70     0.21978      2.672

SUBJ.LAG.CONTEXT STRATUM
  LAG.CONTEXT                         1     4.95220     0.79     4.95220     24.115
  LAG.CONTEXT.NOISE                   1     0.55739     0.09     0.55739      2.714
  RESIDUAL                           18     3.69651     0.59     0.20536      2.497
TOTAL                                20     9.20611     1.47     0.46031      5.597

SUBJ.DISIMSIM.POSITION STRATUM
  DISIMSIM.POSITION                   6     6.07397     0.97     1.01233      7.112
  DISIMSIM.POSITION.NOISE             6     0.58366     0.09     0.09728      0.683
  RESIDUAL                          108    15.37244     2.45     0.14234      1.731
TOTAL                               120    22.03006     3.52     0.18358      2.232

SUBJ.REPET.POSITION STRATUM
  REPET.POSITION                      6     3.89795     0.62     0.64966      4.899
  REPET.POSITION.NOISE                6     0.57719     0.09     0.09620      0.725
  RESIDUAL                          108    14.32333     2.29     0.13262      1.613
TOTAL                               120    18.79847     3.00     0.15665      1.905

SUBJ.LAG.POSITION STRATUM
  LAG.POSITION                        6     2.70464     0.43     0.45077      3.499
  LAG.POSITION.NOISE                  6     0.44515     0.07     0.07419      0.576
  RESIDUAL                          108    13.91187     2.22     0.12881      1.566
TOTAL                               120    17.06165     2.72     0.14218      1.729

SUBJ.CONTEXT.POSITION STRATUM
```

```
  CONTEXT.POSITION                   6     0.36929      0.06     0.06155     0.472
  CONTEXT.POSITION.NOISE             6     0.35850      0.06     0.05975     0.458
  RESIDUAL                         108    14.09045      2.25     0.13047     1.586
TOTAL                              120    14.81823      2.37     0.12349     1.501

SUBJ.DISIMSIM.REPET.LAG STRATUM
  DISIMSIM.REPET.LAG                 1     0.00272      0.00     0.00272     0.008
  DISIMSIM.REPET.LAG.NOISE           1     0.85219      0.14     0.85219     2.592
  RESIDUAL                          18     5.91795      0.95     0.32877     3.997
TOTAL                               20     6.77285      1.08     0.33864     4.117

SUBJ.DISIMSIM.REPET.CONTEXT STRATUM
  DISIMSIM.REPET.CONTEXT             1     0.61569      0.10     0.61569     2.627
  DISIMSIM.REPET.CONTEXT.NOISE
                                     1     0.09572      0.02     0.09572     0.408
  RESIDUAL                          18     4.21940      0.67     0.23441     2.850
TOTAL                               20     4.93082      0.79     0.24654     2.998

SUBJ.DISIMSIM.LAG.CONTEXT STRATUM
  DISIMSIM.LAG.CONTEXT               1     0.34768      0.06     0.34768     1.211
  DISIMSIM.LAG.CONTEXT.NOISE         1     0.00215      0.00     0.00215     0.007
  RESIDUAL                          18     5.16757      0.83     0.28709     3.491
TOTAL                               20     5.51740      0.88     0.27587     3.354

SUBJ.REPET.LAG.CONTEXT STRATUM
  REPET.LAG.CONTEXT                  1     1.38400      0.22     1.38400     7.978
  REPET.LAG.CONTEXT.NOISE            1     0.01540      0.00     0.01540     0.089
  RESIDUAL                          18     3.12263      0.50     0.17348     2.109
TOTAL                               20     4.52202      0.72     0.22610     2.749

SUBJ.DISIMSIM.REPET.POSITION STRATUM
  DISIMSIM.REPET.POSITION            6     3.94345      0.63     0.65724     5.245
  DISIMSIM.REPET.POSITION.NOISE
                                     6     2.20081      0.35     0.36680     2.927
  RESIDUAL                         108    13.53327      2.16     0.12531     1.524
TOTAL                              120    19.67752      3.14     0.16398     1.994

SUBJ.DISIMSIM.LAG.POSITION STRATUM
  DISIMSIM.LAG.POSITION              6     2.81797      0.45     0.46966     3.922
  DISIMSIM.LAG.POSITION.NOISE        6     1.06145      0.17     0.17691     1.477
  RESIDUAL                         108    12.93292      2.07     0.11975     1.456
TOTAL                              120    16.81235      2.68     0.14010     1.703

SUBJ.REPET.LAG.POSITION STRATUM
  REPET.LAG.POSITION                 6     3.30261      0.53     0.55044     4.208
  REPET.LAG.POSITION.NOISE           6     0.50895      0.08     0.08483     0.649
  RESIDUAL                         108    14.12558      2.26     0.13079     1.590
TOTAL                              120    17.93714      2.86     0.14948     1.817

SUBJ.DISIMSIM.CONTEXT.POSITION STRATUM
  DISIMSIM.CONTEXT.POSITION          6     9.90203      1.58     1.65034     9.737
  DISIMSIM.CONTEXT.POSITION.NOISE
                                     6     0.39499      0.06     0.06583     0.388
  RESIDUAL                         108    18.30495      2.92     0.16949     2.061
TOTAL                              120    28.60197      4.57     0.23835     2.898

SUBJ.REPET.CONTEXT.POSITION STRATUM
  REPET.CONTEXT.POSITION             6     0.85634      0.14     0.14272     1.306
  REPET.CONTEXT.POSITION.NOISE
                                     6     0.37260      0.06     0.06210     0.568
  RESIDUAL                         108    11.80282      1.88     0.10929     1.329
TOTAL                              120    13.03175      2.08     0.10860     1.320

SUBJ.LAG.CONTEXT.POSITION STRATUM
  LAG.CONTEXT.POSITION               6     2.89818      0.46     0.48303     4.303
  LAG.CONTEXT.POSITION.NOISE         6     1.03920      0.17     0.17320     1.543
  RESIDUAL                         108    12.12347      1.94     0.11225     1.365
TOTAL                              120    16.06085      2.56     0.13384     1.627

SUBJ.DISIMSIM.REPET.LAG.CONTEXT STRATUM
  DISIMSIM.REPET.LAG.CONTEXT         1     0.13561      0.02     0.13561     0.582
  DISIMSIM.REPET.LAG.CONTEXT.NOISE
                                     1     0.33479      0.05     0.33479     1.437
  RESIDUAL                          18     4.19283      0.67     0.23294     2.832
TOTAL                               20     4.66324      0.74     0.23316     2.835

SUBJ.DISIMSIM.REPET.LAG.POSITION STRATUM
  DISIMSIM.REPET.LAG.POSITION        6     0.55060      0.09     0.09177     0.752
  DISIMSIM.REPET.LAG.POSITION.NOISE
                                     6     0.87285      0.14     0.14548     1.192
  RESIDUAL                         108    13.17757      2.10     0.12201     1.484
TOTAL                              120    14.60102      2.33     0.12168     1.479

SUBJ.DISIMSIM.REPET.CONTEXT.POSITION STRATUM
  DISIMSIM.REPET.CONTEXT.POSITION
                                     6     0.84675      0.14     0.14113     1.143
  DISIMSIM.REPET.CONTEXT.POSITION.NOISE
                                     6     0.16714      0.03     0.02786     0.226
  RESIDUAL                         108    13.33357      2.13     0.12346     1.501
TOTAL                              120    14.34746      2.29     0.11956     1.454

SUBJ.DISIMSIM.LAG.CONTEXT.POSITION STRATUM
  DISIMSIM.LAG.CONTEXT.POSITION
                                     6     3.09080      0.49     0.51513     4.473
  DISIMSIM.LAG.CONTEXT.POSITION.NOISE
                                     6     1.01041      0.16     0.16840     1.462
```

```
  RESIDUAL                       108   12.43912      1.99     0.11518     1.400
TOTAL                            120   16.54033      2.64     0.13784     1.676

SUBJ.REPET.LAG.CONTEXT.POSITION STRATUM
  REPET.LAG.CONTEXT.POSITION       6    0.56628      0.09     0.09438     0.623
  REPET.LAG.CONTEXT.POSITION.NOISE
                                   6    0.65892      0.11     0.10982     0.724
  RESIDUAL                       108   16.37261      2.61     0.15160     1.843
TOTAL                            120   17.59780      2.81     0.14665     1.783

SUBJ.DISIMSIM.REPET.LAG.CONTEXT.POSITION STRATUM
  DISIMSIM.REPET.LAG.CONTEXT.POSITION
                                   6    0.23484      0.04     0.03914     0.476
  DISIMSIM.REPET.LAG.CONTEXT.POSITION.NOISE
                                   6    1.13734      0.18     0.18956     2.305
  RESIDUAL                       108    8.88266      1.42     0.08225
TOTAL                            120   10.25484      1.64     0.08546

GRAND TOTAL                     2239  626.16945    100.00
```

```
***** ANALYSIS OF VARIANCE ***** BOTH CRITICAL LETTERS *** EXPERIMENT 1

SOURCE OF VARIATION                 DF         SS         SS:          MS          VR

SUBJ STRATUM
  NOISE                              1     0.17499       0.17     0.17499       0.169
  RESIDUAL                          18    18.65980      18.08     1.03666      10.868
TOTAL                               19    18.83479      18.25     0.99130      10.392

SUBJ.DISIMSIM STRATUM
  DISIMSIM                           1     6.52796       6.33     6.52796      37.730
  DISIMSIM.NOISE                     1     0.65151       0.63     0.65151       3.766
  RESIDUAL                          18     3.11432       3.02     0.17302       1.814
TOTAL                               20    10.29379       9.98     0.51469       5.396

SUBJ.REPET STRATUM
  REPET                              1     7.24296       7.02     7.24296      43.217
  REPET.NOISE                        1     0.03534       0.03     0.03534       0.211
  RESIDUAL                          18     3.01672       2.92     0.16760       1.757
TOTAL                               20    10.29503       9.98     0.51475       5.396

SUBJ.LAG STRATUM
  LAG                                1    16.52880      16.02    16.52880     111.971
  LAG.NOISE                          1     0.05395       0.05     0.05395       0.365
  RESIDUAL                          18     2.65709       2.57     0.14762       1.548
TOTAL                               20    19.23984      18.64     0.96199      10.085

SUBJ.CONTEXT STRATUM
  CONTEXT                            1     0.95758       0.93     0.95758       4.877
  CONTEXT.NOISE                      1     0.28364       0.27     0.28364       1.445
  RESIDUAL                          18     3.53438       3.43     0.19635       2.059
TOTAL                               20     4.77560       4.63     0.23878       2.503

SUBJ.DISIMSIM.REPET STRATUM
  DISIMSIM.REPET                     1     0.97252       0.94     0.97252       5.295
  DISIMSIM.REPET.NOISE               1     0.01207       0.01     0.01207       0.066
  RESIDUAL                          18     3.30607       3.20     0.18367       1.926
TOTAL                               20     4.29065       4.16     0.21453       2.249

SUBJ.DISIMSIM.LAG STRATUM
  DISIMSIM.LAG                       1     0.19796       0.19     0.19796       3.593
  DISIMSIM.LAG.NOISE                 1     0.00001       0.00     0.00001       0.000
  RESIDUAL                          18     0.99167       0.96     0.05509       0.578
TOTAL                               20     1.18964       1.15     0.05948       0.624

SUBJ.REPET.LAG STRATUM
  REPET.LAG                          1     2.48671       2.41     2.48671      10.649
  REPET.LAG.NOISE                    1     0.74334       0.72     0.74334       3.183
  RESIDUAL                          18     4.20332       4.07     0.23352       2.448
TOTAL                               20     7.43337       7.20     0.37167       3.896

SUBJ.DISIMSIM.CONTEXT STRATUM
  DISIMSIM.CONTEXT                   1     0.92784       0.90     0.92784      10.197
  DISIMSIM.CONTEXT.NOISE             1     1.70893       1.66     1.70893      18.781
  RESIDUAL                          18     1.63784       1.59     0.09099       0.954
TOTAL                               20     4.27460       4.14     0.21373       2.241

SUBJ.REPET.CONTEXT STRATUM
  REPET.CONTEXT                      1     0.53948       0.52     0.53948       3.831
  REPET.CONTEXT.NOISE                1     0.13584       0.13     0.13584       0.965
  RESIDUAL                          18     2.53504       2.46     0.14084       1.476
TOTAL                               20     3.21036       3.11     0.16052       1.683

SUBJ.LAG.CONTEXT STRATUM
  LAG.CONTEXT                        1     0.56171       0.54     0.56171       4.341
  LAG.CONTEXT.NOISE                  1     0.18408       0.18     0.18408       1.422
  RESIDUAL                          18     2.32939       2.26     0.12941       1.357
TOTAL                               20     3.07518       2.98     0.15376       1.612

SUBJ.DISIMSIM.REPET.LAG STRATUM
  DISIMSIM.REPET.LAG                 1     0.09042       0.09     0.09042       0.449
  DISIMSIM.REPET.LAG.NOISE           1     0.11321       0.11     0.11321       0.562
  RESIDUAL                          18     3.62667       3.51     0.20148       2.112
TOTAL                               20     3.83030       3.71     0.19152       2.008

SUBJ.DISIMSIM.REPET.CONTEXT STRATUM
  DISIMSIM.REPET.CONTEXT             1     0.16196       0.16     0.16196       1.038
  DISIMSIM.REPET.CONTEXT.NOISE
                                     1     0.02469       0.02     0.02469       0.158
  RESIDUAL                          18     2.80979       2.72     0.15610       1.636
TOTAL                               20     2.99644       2.90     0.14982       1.571

SUBJ.DISIMSIM.LAG.CONTEXT STRATUM
  DISIMSIM.LAG.CONTEXT               1     0.25600       0.25     0.25600       1.620
  DISIMSIM.LAG.CONTEXT.NOISE         1     0.55903       0.54     0.55903       3.538
  RESIDUAL                          18     2.84450       2.76     0.15803       1.657
TOTAL                               20     3.65954       3.55     0.18298       1.918

SUBJ.REPET.LAG.CONTEXT STRATUM
  REPET.LAG.CONTEXT                  1     0.05369       0.05     0.05369       0.297
  REPET.LAG.CONTEXT.NOISE            1     0.03839       0.04     0.03839       0.212
  RESIDUAL                          18     3.25420       3.15     0.18079       1.895
TOTAL                               20     3.34628       3.24     0.16731       1.754

SUBJ.DISIMSIM.REPET.LAG.CONTEXT STRATUM
```

```
  DISIMSIM.REPET.LAG.CONTEXT       1     0.27232     0.26     0.27232     2.855
  DISIMSIM.REPET.LAG.CONTEXT.NOISE
                                   1     0.45715     0.44     0.45715     4.793
  RESIDUAL                        18     1.71696     1.66     0.09539
TOTAL                             20     2.44643     2.37     0.12232

GRAND TOTAL                      319   103.19184   100.00
```

```
***** ANALYSIS OF VARIANCE ***** AT LEAST ONE CRITICAL LETTER *** EXP. 1

SOURCE OF VARIATION                     DF          SS      SS:          MS        VR

SUBJ STRATUM
  NOISE                                  1     0.39875     0.70     0.39875     0.616
  RESIDUAL                              18    11.65902    20.57     0.64772     8.343
TOTAL                                   19    12.05777    21.27     0.63462     8.175

SUBJ.DISIMSIM STRATUM
  DISIMSIM                               1     4.63781     8.18     4.63781    30.721
  DISIMSIM.NOISE                         1     0.21249     0.37     0.21249     1.408
  RESIDUAL                              18     2.71738     4.79     0.15097     1.945
TOTAL                                   20     7.56768    13.35     0.37838     4.874

SUBJ.REPET STRATUM
  REPET                                  1     3.24496     5.72     3.24496    32.456
  REPET.NOISE                            1     0.02083     0.04     0.02083     0.208
  RESIDUAL                              18     1.79964     3.17     0.09998     1.288
TOTAL                                   20     5.06543     8.94     0.25327     3.262

SUBJ.LAG STRATUM
  LAG                                    1     4.10192     7.24     4.10192    41.205
  LAG.NOISE                              1     0.00602     0.01     0.00602     0.060
  RESIDUAL                              18     1.79190     3.16     0.09955     1.282
TOTAL                                   20     5.89983    10.41     0.29499     3.800

SUBJ.CONTEXT STRATUM
  CONTEXT                                1     0.67070     1.18     0.67070     7.547
  CONTEXT.NOISE                          1     0.24620     0.43     0.24620     2.770
  RESIDUAL                              18     1.59974     2.82     0.08887     1.145
TOTAL                                   20     2.51663     4.44     0.12583     1.621

SUBJ.DISIMSIM.REPET STRATUM
  DISIMSIM.REPET                         1     0.49723     0.88     0.49723     6.518
  DISIMSIM.REPET.NOISE                   1     0.08541     0.15     0.08541     1.120
  RESIDUAL                              18     1.37318     2.42     0.07629     0.983
TOTAL                                   20     1.95582     3.45     0.09779     1.260

SUBJ.DISIMSIM.LAG STRATUM
  DISIMSIM.LAG                           1     0.31450     0.55     0.31450     5.577
  DISIMSIM.LAG.NOISE                     1     0.03374     0.06     0.03374     0.598
  RESIDUAL                              18     1.01507     1.79     0.05639     0.726
TOTAL                                   20     1.36332     2.40     0.06817     0.878

SUBJ.REPET.LAG STRATUM
  REPET.LAG                              1     1.15777     2.04     1.15777     8.268
  REPET.LAG.NOISE                        1     0.10974     0.19     0.10974     0.784
  RESIDUAL                              18     2.52058     4.45     0.14003     1.804
TOTAL                                   20     3.78809     6.68     0.18940     2.440

SUBJ.DISIMSIM.CONTEXT STRATUM
  DISIMSIM.CONTEXT                       1     0.40898     0.72     0.40898     7.641
  DISIMSIM.CONTEXT.NOISE                 1     0.99614     1.76     0.99614    18.610
  RESIDUAL                              18     0.96349     1.70     0.05353     0.689
TOTAL                                   20     2.36861     4.18     0.11843     1.526

SUBJ.REPET.CONTEXT STRATUM
  REPET.CONTEXT                          1     0.54946     0.97     0.54946     6.304
  REPET.CONTEXT.NOISE                    1     0.05741     0.10     0.05741     0.659
  RESIDUAL                              18     1.56895     2.77     0.08716     1.123
TOTAL                                   20     2.17582     3.84     0.10879     1.401

SUBJ.LAG.CONTEXT STRATUM
  LAG.CONTEXT                            1     0.42413     0.75     0.42413     4.766
  LAG.CONTEXT.NOISE                      1     0.29622     0.52     0.29622     3.329
  RESIDUAL                              18     1.60181     2.83     0.08899     1.146
TOTAL                                   20     2.32216     4.10     0.11611     1.496

SUBJ.DISIMSIM.REPET.LAG STRATUM
  DISIMSIM.REPET.LAG                     1     0.24299     0.43     0.24299     2.199
  DISIMSIM.REPET.LAG.NOISE               1     0.36154     0.64     0.36154     3.272
  RESIDUAL                              18     1.98871     3.51     0.11048     1.423
TOTAL                                   20     2.59324     4.57     0.12966     1.670

SUBJ.DISIMSIM.REPET.CONTEXT STRATUM
  DISIMSIM.REPET.CONTEXT                 1     0.07003     0.12     0.07003     0.857
  DISIMSIM.REPET.CONTEXT.NOISE
                                         1     0.00480     0.01     0.00480     0.059

  RESIDUAL                              18     1.47061     2.59     0.08170     1.052
TOTAL                                   20     1.54545     2.73     0.07727     0.995

SUBJ.DISIMSIM.LAG.CONTEXT STRATUM
  DISIMSIM.LAG.CONTEXT                   1     0.00000     0.00     0.00000     0.000
  DISIMSIM.LAG.CONTEXT.NOISE             1     0.48035     0.85     0.48035     4.995
  RESIDUAL                              18     1.73094     3.05     0.09616     1.239
TOTAL                                   20     2.21129     3.90     0.11056     1.424

SUBJ.REPET.LAG.CONTEXT STRATUM
  REPET.LAG.CONTEXT                      1     0.07552     0.13     0.07552     0.864
  REPET.LAG.CONTEXT.NOISE                1     0.01521     0.03     0.01521     0.174
  RESIDUAL                              18     1.57384     2.78     0.08744     1.126
TOTAL                                   20     1.66457     2.94     0.08323     1.072

SUBJ.DISIMSIM.REPET.LAG.CONTEXT STRATUM
```

```
  DISIMSIM.REPET.LAG.CONTEXT       1      0.11063       0.20      0.11063      1.425
  DISIMSIM.REPET.LAG.CONTEXT.NOISE
                                   1      0.08607       0.15      0.08607      1.109
  RESIDUAL                        18      1.39740       2.46      0.07763
TOTAL                             20      1.59410       2.81      0.07970

GRAND TOTAL                      319     56.68982     100.00
```

```
***** ANALYSIS OF VARIANCE *****EXPERIMENT 2

VARIATE: SCORE

SOURCE OF VARIATION                  DF          SS         SS:           MS          VR

SUBJ STRATUM
  NOISE                               1     10.3143        0.46      10.3143       0.439
  RESIDUAL                           18    422.9518       19.06      23.4973     104.679
TOTAL                                19    433.2661       19.52      22.8035     101.588

SUBJ.DISIMSIM STRATUM
  DISIMSIM                            1     10.5875        0.48      10.5875      12.460
  DISIMSIM.NOISE                      1      1.0286        0.05       1.0286       1.211
  RESIDUAL                           18     15.2946        0.69       0.8497       3.785
TOTAL                                20     26.9107        1.21       1.3455       5.994

SUBJ.REPET STRATUM
  REPET                               1     20.0643        0.90      20.0643      13.587
  REPET.NOISE                         1      0.0161        0.00       0.0161       0.011
  RESIDUAL                           18     26.5804        1.20       1.4767       6.579
TOTAL                                20     46.6607        2.10       2.3330      10.393

SUBJ.LAG STRATUM
  LAG                                 1      6.8643        0.31       6.8643       4.270
  LAG.NOISE                           1      1.5018        0.07       1.5018       0.934
  RESIDUAL                           18     28.9375        1.30       1.6076       7.162
TOTAL                                20     37.3036        1.68       1.8652       8.309

SUBJ.CONTEXT STRATUM
  CONTEXT                             1      0.8643        0.04       0.8643       1.333
  CONTEXT.NOISE                       1      0.0875        0.00       0.0875       0.135
  RESIDUAL                           18     11.6732        0.53       0.6485       2.889
TOTAL                                20     12.6250        0.57       0.6313       2.812

SUBJ.POSITION STRATUM
  POSITION                            6    479.9214       21.63      79.9869      54.430
  POSITION.NOISE                      6      3.1357        0.14       0.5226       0.356
  RESIDUAL                          108    158.7107        7.15       1.4695       6.547
TOTAL                               120    641.7679       28.92       5.3481      23.825

SUBJ.DISIMSIM.REPET STRATUM
  DISIMSIM.REPET                      1      0.7143        0.03       0.7143       0.738
  DISIMSIM.REPET.NOISE                1      0.0875        0.00       0.0875       0.090
  RESIDUAL                           18     17.4304        0.79       0.9684       4.314
TOTAL                                20     18.2321        0.82       0.9116       4.061

SUBJ.DISIMSIM.LAG STRATUM
  DISIMSIM.LAG                        1      1.2071        0.05       1.2071       1.433
  DISIMSIM.LAG.NOISE                  1      0.0018        0.00       0.0018       0.002
  RESIDUAL                           18     15.1661        0.68       0.8426       3.754
TOTAL                                20     16.3750        0.74       0.8188       3.647

SUBJ.REPET.LAG STRATUM
  REPET.LAG                           1     22.8018        1.03      22.8018      18.894
  REPET.LAG.NOISE                     1      0.0286        0.00       0.0286       0.024
  RESIDUAL                           18     21.7232        0.98       1.2068       5.376
TOTAL                                20     44.5536        2.01       2.2277       9.924

SUBJ.DISIMSIM.CONTEXT STRATUM
  DISIMSIM.CONTEXT                    1     84.8643        3.82      84.8643      55.314
  DISIMSIM.CONTEXT.NOISE              1      1.5018        0.07       1.5018       0.979
  RESIDUAL                           18     27.6161        1.24       1.5342       6.835
TOTAL                                20    113.9821        5.14       5.6991      25.389

SUBJ.REPET.CONTEXT STRATUM
  REPET.CONTEXT                       1      3.0018        0.14       3.0018       2.318
  REPET.CONTEXT.NOISE                 1      0.0643        0.00       0.0643       0.050
  RESIDUAL                           18     23.3089        1.05       1.2949       5.769
TOTAL                                20     26.3750        1.19       1.3187       5.875

SUBJ.LAG.CONTEXT STRATUM
  LAG.CONTEXT                         1      5.0161        0.23       5.0161       9.603
  LAG.CONTEXT.NOISE                   1      0.0286        0.00       0.0286       0.055
  RESIDUAL                           18      9.4018        0.42       0.5223       2.327
TOTAL                                20     14.4464        0.65       0.7223       3.218

SUBJ.DISIMSIM.POSITION STRATUM
  DISIMSIM.POSITION                   6      8.4750        0.38       1.4125       4.152
  DISIMSIM.POSITION.NOISE             6      1.3714        0.06       0.2286       0.672
  RESIDUAL                          108     36.7429        1.66       0.3402       1.516
TOTAL                               120     46.5893        2.10       0.3882       1.730

SUBJ.REPET.POSITION STRATUM
  REPET.POSITION                      6      8.5732        0.39       1.4289       4.340
  REPET.POSITION.NOISE                6      1.2089        0.05       0.2015       0.612
  RESIDUAL                          108     35.5571        1.60       0.3292       1.467
TOTAL                               120     45.3393        2.04       0.3778       1.683

SUBJ.LAG.POSITION STRATUM
  LAG.POSITION                        6      7.6982        0.35       1.2830       3.255
  LAG.POSITION.NOISE                  6      4.1732        0.19       0.6955       1.764
  RESIDUAL                          108     42.5750        1.92       0.3942       1.756
TOTAL                               120     54.4464        2.45       0.4537       2.021
```

```
SUBJ.CONTEXT.POSITION STRATUM
  CONTEXT.POSITION                        6      3.9107      0.18      0.6518     1.818
  CONTEXT.POSITION.NOISE                  6      2.7500      0.12      0.4583     1.279
  RESIDUAL                              108     38.7143      1.74      0.3585     1.597
TOTAL                                   120     45.3750      2.04      0.3781     1.685

SUBJ.DISIMSIM.REPET.LAG STRATUM
  DISIMSIM.REPET.LAG                      1      0.3018      0.01      0.3018     0.374
  DISIMSIM.REPET.LAG.NOISE                1      0.0071      0.00      0.0071     0.009
  RESIDUAL                               18     14.5304      0.65      0.8072     3.596
TOTAL                                    20     14.8393      0.67      0.7420     3.305

SUBJ.DISIMSIM.REPET.CONTEXT STRATUM
  DISIMSIM.REPET.CONTEXT                  1      0.5161      0.02      0.5161     0.776
  DISIMSIM.REPET.CONTEXT.NOISE
                                          1      0.4571      0.02      0.4571     0.687
  RESIDUAL                               18     11.9732      0.54      0.6652     2.963
TOTAL                                    20     12.9464      0.58      0.6473     2.884

SUBJ.DISIMSIM.LAG.CONTEXT STRATUM
  DISIMSIM.LAG.CONTEXT                    1      2.1875      0.10      2.1875     3.484
  DISIMSIM.LAG.CONTEXT.NOISE              1      0.4571      0.02      0.4571     0.728
  RESIDUAL                               18     11.3018      0.51      0.6279     2.797
TOTAL                                    20     13.9464      0.63      0.6973     3.107

SUBJ.REPET.LAG.CONTEXT STRATUM
  REPET.LAG.CONTEXT                       1      1.4000      0.06      1.4000     1.987
  REPET.LAG.CONTEXT.NOISE                 1      0.4018      0.02      0.4018     0.570
  RESIDUAL                               18     12.6804      0.57      0.7045     3.138
TOTAL                                    20     14.4821      0.65      0.7241     3.226

SUBJ.DISIMSIM.REPET.POSITION STRATUM
  DISIMSIM.REPET.POSITION                 6      1.3982      0.06      0.2330     0.748
  DISIMSIM.REPET.POSITION.NOISE
                                          6      1.4875      0.07      0.2479     0.796
  RESIDUAL                              108     33.6321      1.52      0.3114     1.387
TOTAL                                   120     36.5179      1.65      0.3043     1.356

SUBJ.DISIMSIM.LAG.POSITION STRATUM
  DISIMSIM.LAG.POSITION                   6      4.4304      0.20      0.7384     2.786
  DISIMSIM.LAG.POSITION.NOISE             6      1.5732      0.07      0.2622     0.989
  RESIDUAL                              108     28.6214      1.29      0.2650     1.181
TOTAL                                   120     34.6250      1.56      0.2885     1.285

SUBJ.REPET.LAG.POSITION STRATUM
  REPET.LAG.POSITION                      6     13.2857      0.60      2.2143     5.289
  REPET.LAG.POSITION.NOISE                6      1.9464      0.09      0.3244     0.775
  RESIDUAL                              108     45.2143      2.04      0.4187     1.865
TOTAL                                   120     60.4464      2.72      0.5037     2.244

SUBJ.DISIMSIM.CONTEXT.POSITION STRATUM
  DISIMSIM.CONTEXT.POSITION               6     53.3107      2.40      8.8851    16.970
  DISIMSIM.CONTEXT.POSITION.NOISE
                                          6      1.9107      0.09      0.3185     0.608
  RESIDUAL                              108     56.5464      2.55      0.5236     2.332
TOTAL                                   120    111.7679      5.04      0.9314     4.149

SUBJ.REPET.CONTEXT.POSITION STRATUM
  REPET.CONTEXT.POSITION                  6      3.4482      0.16      0.5747     1.761
  REPET.CONTEXT.POSITION.NOISE
                                          6      4.1732      0.19      0.6955     2.131
  RESIDUAL                              108     35.2536      1.59      0.3264     1.454
TOTAL                                   120     42.8750      1.93      0.3573     1.592

SUBJ.LAG.CONTEXT.POSITION STRATUM
  LAG.CONTEXT.POSITION                    6      5.5339      0.25      0.9223     2.668
  LAG.CONTEXT.POSITION.NOISE              6      2.1839      0.10      0.3640     1.053
  RESIDUAL                              108     37.3357      1.68      0.3457     1.540
TOTAL                                   120     45.0536      2.03      0.3754     1.673

SUBJ.DISIMSIM.REPET.LAG.CONTEXT STRATUM
  DISIMSIM.REPET.LAG.CONTEXT              1      0.1786      0.01      0.1786     0.405
  DISIMSIM.REPET.LAG.CONTEXT.NOISE
                                          1      0.7875      0.04      0.7875     1.784
  RESIDUAL                               18      7.9446      0.36      0.4414     1.966
TOTAL                                    20      8.9107      0.40      0.4455     1.985

SUBJ.DISIMSIM.REPET.LAG.POSITION STRATUM
  DISIMSIM.REPET.LAG.POSITION             6      1.2607      0.06      0.2101     0.653
  DISIMSIM.REPET.LAG.POSITION.NOISE
                                          6      1.4179      0.06      0.2363     0.735
  RESIDUAL                              108     34.7321      1.57      0.3216     1.433
TOTAL                                   120     37.4107      1.69      0.3118     1.389

SUBJ.DISIMSIM.REPET.CONTEXT.POSITION STRATUM
  DISIMSIM.REPET.CONTEXT.POSITION
                                          6      5.7839      0.26      0.9640     3.106

  DISIMSIM.REPET.CONTEXT.POSITION.NOISE
                                          6      2.7554      0.12      0.4592     1.480
  RESIDUAL                              108     33.5143      1.51      0.3103     1.382
TOTAL                                   120     42.0536      1.89      0.3504     1.561

SUBJ.DISIMSIM.LAG.CONTEXT.POSITION STRATUM
  DISIMSIM.LAG.CONTEXT.POSITION
                                          6      2.9625      0.13      0.4937     1.086

  DISIMSIM.LAG.CONTEXT.POSITION.NOISE
```

```
                                   6      0.7304      0.03      0.1217     0.268
  RESIDUAL                       108     49.1107      2.21      0.4547     2.026
TOTAL                            120     52.8036      2.38      0.4400     1.960

SUBJ.REPET.LAG.CONTEXT.POSITION STRATUM
  REPET.LAG.CONTEXT.POSITION       6      6.4000      0.29      1.0667     3.792
  REPET.LAG.CONTEXT.POSITION.NOISE
                                   6      1.4857      0.07      0.2476     0.880
  RESIDUAL                       108     30.3821      1.37      0.2813     1.253
TOTAL                            120     38.2679      1.72      0.3189     1.421

SUBJ.DISIMSIM.REPET.LAG.CONTEXT.POSITION STRATUM
  DISIMSIM.REPET.LAG.CONTEXT.POSITION
                                   6      2.3214      0.10      0.3869     1.724
  DISIMSIM.REPET.LAG.CONTEXT.POSITION.NOISE
                                   6      1.5250      0.07      0.2542     1.132
  RESIDUAL                       108     24.2429      1.09      0.2245
TOTAL                            120     28.0893      1.27      0.2341

GRAND TOTAL                     2239   2219.2839    100.00
```

```
***** ANALYSIS OF VARIANCE ***** BOTH CRITICAL LETTERS *** EXPERIMENT 2

SOURCE OF VARIATION                 DF        SS        SS:         MS        VR

SUBJ STRATUM
  NOISE                              1      6.050      0.40      6.050     0.238
  RESIDUAL                          18    457.500     29.87     25.417    11.024
TOTAL                               19    463.550     30.27     24.397    10.582

SUBJ.DISIMSIM STRATUM
  DISIMSIM                           1     61.250      4.00     61.250    25.462
  DISIMSIM.NOISE                     1      2.450      0.16      2.450     1.018
  RESIDUAL                          18     43.300      2.83      2.406     1.043
TOTAL                               20    107.000      6.99      5.350     2.320

SUBJ.REPET STRATUM
  REPET                              1     61.250      4.00     61.250    22.639
  REPET.NOISE                        1      0.050      0.00      0.050     0.018
  RESIDUAL                          18     48.700      3.18      2.706     1.173
TOTAL                               20    110.000      7.18      5.500     2.386

SUBJ.LAG STRATUM
  LAG                                1    135.200      8.83    135.200    35.475
  LAG.NOISE                          1      0.200      0.01      0.200     0.052
  RESIDUAL                          18     68.600      4.48      3.811     1.653
TOTAL                               20    204.000     13.32     10.200     4.424

SUBJ.CONTEXT STRATUM
  CONTEXT                            1     20.000      1.31     20.000     6.020
  CONTEXT.NOISE                      1      3.200      0.21      3.200     0.963
  RESIDUAL                          18     59.800      3.90      3.322     1.441
TOTAL                               20     83.000      5.42      4.150     1.800

SUBJ.DISIMSIM.REPET STRATUM
  DISIMSIM.REPET                     1      2.450      0.16      2.450     1.048
  DISIMSIM.REPET.NOISE               1      2.450      0.16      2.450     1.048
  RESIDUAL                          18     42.100      2.75      2.339     1.014
TOTAL                               20     47.000      3.07      2.350     1.019

SUBJ.DISIMSIM.LAG STRATUM
  DISIMSIM.LAG                       1      0.000      0.00      0.000     0.000
  DISIMSIM.LAG.NOISE                 1      0.200      0.01      0.200     0.173
  RESIDUAL                          18     20.800      1.36      1.156     0.501
TOTAL                               20     21.000      1.37      1.050     0.455

SUBJ.REPET.LAG STRATUM
  REPET.LAG                          1     24.200      1.58     24.200     8.219
  REPET.LAG.NOISE                    1      0.800      0.05      0.800     0.272
  RESIDUAL                          18     53.000      3.46      2.944     1.277
TOTAL                               20     78.000      5.09      3.900     1.692

SUBJ.DISIMSIM.CONTEXT STRATUM
  DISIMSIM.CONTEXT                   1     24.200      1.58     24.200     7.835
  DISIMSIM.CONTEXT.NOISE             1      0.200      0.01      0.200     0.065
  RESIDUAL                          18     55.600      3.63      3.089     1.340
TOTAL                               20     80.000      5.22      4.000     1.735

SUBJ.REPET.CONTEXT STRATUM
  REPET.CONTEXT                      1      7.200      0.47      7.200     2.757
  REPET.CONTEXT.NOISE                1      0.800      0.05      0.800     0.306
  RESIDUAL                          18     47.000      3.07      2.611     1.133
TOTAL                               20     55.000      3.59      2.750     1.193

SUBJ.LAG.CONTEXT STRATUM
  LAG.CONTEXT                        1      2.450      0.16      2.450     0.932
  LAG.CONTEXT.NOISE                  1      1.250      0.08      1.250     0.476
  RESIDUAL                          18     47.300      3.09      2.628     1.140
TOTAL                               20     51.000      3.33      2.550     1.106

SUBJ.DISIMSIM.REPET.LAG STRATUM
  DISIMSIM.REPET.LAG                 1      0.000      0.00      0.000     0.000
  DISIMSIM.REPET.LAG.NOISE           1      0.200      0.01      0.200     0.110
  RESIDUAL                          18     32.800      2.14      1.822     0.790
TOTAL                               20     33.000      2.15      1.650     0.716

SUBJ.DISIMSIM.REPET.CONTEXT STRATUM
  DISIMSIM.REPET.CONTEXT             1      0.000      0.00      0.000     0.000
  DISIMSIM.REPET.CONTEXT.NOISE
                                     1      3.200      0.21      3.200     2.149
  RESIDUAL                          18     26.800      1.75      1.489     0.646
TOTAL                               20     30.000      1.96      1.500     0.651

SUBJ.DISIMSIM.LAG.CONTEXT STRATUM
  DISIMSIM.LAG.CONTEXT               1      8.450      0.55      8.450     2.473
  DISIMSIM.LAG.CONTEXT.NOISE         1      0.050      0.00      0.050     0.015
  RESIDUAL                          18     61.500      4.02      3.417     1.482
TOTAL                               20     70.000      4.57      3.500     1.518

SUBJ.REPET.LAG.CONTEXT STRATUM
  REPET.LAG.CONTEXT                  1      4.050      0.26      4.050     1.894
  REPET.LAG.CONTEXT.NOISE            1      8.450      0.55      8.450     3.951
  RESIDUAL                          18     38.500      2.51      2.139     0.928
TOTAL                               20     51.000      3.33      2.550     1.106

SUBJ.DISIMSIM.REPET.LAG.CONTEXT STRATUM
```

```
  DISIMSIM.REPET.LAG.CONTEXT        1       6.050      0.40       6.050      2.624
  DISIMSIM.REPET.LAG.CONTEXT.NOISE
                                    1       0.450      0.03       0.450      0.195
  RESIDUAL                         18      41.500      2.71       2.306
TOTAL                              20      48.000      3.13       2.400

GRAND TOTAL                       319    1531.550    100.00
```

```
***** ANALYSIS OF VARIANCE ***** AT LEAST ONE CRITICAL LETTER  *** EXP. 2

SOURCE OF VARIATION                           DF           SS       SS:           MS        VR

SUBJ STRATUM
  NOISE                                        1      13.2031      1.58      13.2031     0.856
  RESIDUAL                                    18     277.7063     33.16      15.4281    17.938
TOTAL                                         19     290.9094     34.73      15.3110    17.802

SUBJ.DISIMSIM STRATUM
  DISIMSIM                                     1      37.1281      4.43      37.1281    28.768
  DISIMSIM.NOISE                               1       1.9531      0.23       1.9531     1.513
  RESIDUAL                                    18      23.2312      2.77       1.2906     1.501
TOTAL                                         20      62.3125      7.44       3.1156     3.623

SUBJ.REPET STRATUM
  REPET                                        1      24.7531      2.96      24.7531    12.340
  REPET.NOISE                                  1       0.7031      0.08       0.7031     0.351
  RESIDUAL                                    18      36.1062      4.31       2.0059     2.332
TOTAL                                         20      61.5625      7.35       3.0781     3.579

SUBJ.LAG STRATUM
  LAG                                          1      22.5781      2.70      22.5781    10.133
  LAG.NOISE                                    1       0.3781      0.05       0.3781     0.170
  RESIDUAL                                    18      40.1063      4.79       2.2281     2.591
TOTAL                                         20      63.0625      7.53       3.1531     3.666

SUBJ.CONTEXT STRATUM
  CONTEXT                                      1       8.1281      0.97       8.1281     5.874
  CONTEXT.NOISE                                1       2.2781      0.27       2.2781     1.646
  RESIDUAL                                    18      24.9063      2.97       1.3837     1.609
TOTAL                                         20      35.3125      4.22       1.7656     2.053

SUBJ.DISIMSIM.REPET STRATUM
  DISIMSIM.REPET                               1       2.2781      0.27       2.2781     1.339
  DISIMSIM.REPET.NOISE                         1       1.6531      0.20       1.6531     0.971
  RESIDUAL                                    18      30.6312      3.66       1.7017     1.979
TOTAL                                         20      34.5625      4.13       1.7281     2.009

SUBJ.DISIMSIM.LAG STRATUM
  DISIMSIM.LAG                                 1       0.0031      0.00       0.0031     0.005
  DISIMSIM.LAG.NOISE                           1       0.0781      0.01       0.0781     0.122
  RESIDUAL                                    18      11.4812      1.37       0.6378     0.742
TOTAL                                         20      11.5625      1.38       0.5781     0.672

SUBJ.REPET.LAG STRATUM
  REPET.LAG                                    1      10.1531      1.21      10.1531     6.792
  REPET.LAG.NOISE                              1       0.2531      0.03       0.2531     0.169
  RESIDUAL                                    18      26.9063      3.21       1.4948     1.738
TOTAL                                         20      37.3125      4.45       1.8656     2.169

SUBJ.DISIMSIM.CONTEXT STRATUM
  DISIMSIM.CONTEXT                             1      14.8781      1.78      14.8781     7.433
  DISIMSIM.CONTEXT.NOISE                       1       0.9031      0.11       0.9031     0.451
  RESIDUAL                                    18      36.0313      4.30       2.0017     2.327
TOTAL                                         20      51.8125      6.19       2.5906     3.012

SUBJ.REPET.CONTEXT STRATUM
  REPET.CONTEXT                                1      10.8781      1.30      10.8781     8.277
  REPET.CONTEXT.NOISE                          1       0.5281      0.06       0.5281     0.402
  RESIDUAL                                    18      23.6563      2.82       1.3142     1.528
TOTAL                                         20      35.0625      4.19       1.7531     2.038

SUBJ.LAG.CONTEXT STRATUM
  LAG.CONTEXT                                  1       1.6531      0.20       1.6531     0.922
  LAG.CONTEXT.NOISE                            1       0.1531      0.02       0.1531     0.085
  RESIDUAL                                    18      32.2563      3.85       1.7920     2.084
TOTAL                                         20      34.0625      4.07       1.7031     1.980

SUBJ.DISIMSIM.REPET.LAG STRATUM
  DISIMSIM.REPET.LAG                           1       0.5281      0.06       0.5281     0.376
  DISIMSIM.REPET.LAG.NOISE                     1       0.0031      0.00       0.0031     0.002
  RESIDUAL                                    18      25.2812      3.02       1.4045     1.633
TOTAL                                         20      25.8125      3.08       1.2906     1.501

SUBJ.DISIMSIM.REPET.CONTEXT STRATUM
  DISIMSIM.REPET.CONTEXT                       1       0.5281      0.06       0.5281     0.490
  DISIMSIM.REPET.CONTEXT.NOISE
                                               1       1.6531      0.20       1.6531     1.535
  RESIDUAL                                    18      19.3812      2.31       1.0767     1.252
TOTAL                                         20      21.5625      2.57       1.0781     1.254

SUBJ.DISIMSIM.LAG.CONTEXT STRATUM
  DISIMSIM.LAG.CONTEXT                         1       3.0031      0.36       3.0031     2.511
  DISIMSIM.LAG.CONTEXT.NOISE                   1       0.5281      0.06       0.5281     0.442
  RESIDUAL                                    18      21.5312      2.57       1.1962     1.391
TOTAL                                         20      25.0625      2.99       1.2531     1.457

SUBJ.REPET.LAG.CONTEXT STRATUM
  REPET.LAG.CONTEXT                            1       8.1281      0.97       8.1281     8.918
  REPET.LAG.CONTEXT.NOISE                      1       4.2781      0.51       4.2781     4.694
  RESIDUAL                                    18      16.4063      1.96       0.9115     1.060
TOTAL                                         20      28.8125      3.44       1.4406     1.675

SUBJ.DISIMSIM.REPET.LAG.CONTEXT STRATUM
```

```
  DISIMSIM.REPET.LAG.CONTEXT          1        2.6281        0.31        2.6281        3.056
  DISIMSIM.REPET.LAG.CONTEXT.NOISE
                                      1        0.7031        0.08        0.7031        0.818
  RESIDUAL                           18       15.4812        1.85        0.8601
TOTAL                                20       18.8125        2.25        0.9406

GRAND TOTAL                         319      837.5969      100.00
```

```
***** ANALYSIS OF VARIANCE *****   EXPERIMENT 3

SOURCE OF VARIATION                 DF          SS        SS%          MS         VR

SUBJ STRATUM
  NOISE                              1      7.0225       0.49      7.0225      1.497
  RESIDUAL                          18     84.4300       5.90      4.6906     12.262
TOTAL                               19     91.4525       6.39      4.8133     12.583

SUBJ.ARTIC STRATUM
  ARTIC                              1      1.6900       0.12      1.6900      1.222
  ARTIC.NOISE                        1      1.6900       0.12      1.6900      1.222
  RESIDUAL                          18     24.8950       1.74      1.3831      3.616
TOTAL                               20     28.2750       1.97      1.4137      3.696

SUBJ.RATE STRATUM
  RATE                               1    103.0225       7.20    103.0225     28.670
  RATE.NOISE                         1      0.1225       0.01      0.1225      0.034
  RESIDUAL                          18     64.6800       4.52      3.5933      9.393
TOTAL                               20    167.8250      11.72      8.3912     21.936

SUBJ.DELAY STRATUM
  DELAY                              1      3.8025       0.27      3.8025      3.021
  DELAY.NOISE                        1      0.0625       0.00      0.0625      0.050
  RESIDUAL                          18     22.6600       1.58      1.2589      3.291
TOTAL                               20     26.5250       1.85      1.3262      3.467

SUBJ.CONFUSIO STRATUM
  CONFUSIO                           1    119.9025       8.37    119.9025     26.524
  CONFUSIO.NOISE                     1      0.0025       0.00      0.0025      0.001
  RESIDUAL                          18     81.3700       5.68      4.5206     11.817
TOTAL                               20    201.2750      14.06     10.0638     26.308

SUBJ.POSITION STRATUM
  POSITION                           4    176.4588      12.33     44.1147     70.066
  POSITION.NOISE                     4      1.1838       0.08      0.2959      0.470
  RESIDUAL                          72     45.3325       3.17      0.6296      1.646
TOTAL                               80    222.9750      15.57      2.7872      7.286

SUBJ.ARTIC.RATE STRATUM
  ARTIC.RATE                         1      0.8100       0.06      0.8100      0.889
  ARTIC.RATE.NOISE                   1      0.0100       0.00      0.0100      0.011
  RESIDUAL                          18     16.4050       1.15      0.9114      2.382
TOTAL                               20     17.2250       1.20      0.8612      2.251

SUBJ.ARTIC.DELAY STRATUM
  ARTIC.DELAY                        1      0.3600       0.03      0.3600      0.472
  ARTIC.DELAY.NOISE                  1      0.2500       0.02      0.2500      0.328
  RESIDUAL                          18     13.7150       0.96      0.7619      1.992
TOTAL                               20     14.3250       1.00      0.7163      1.872

SUBJ.RATE.DELAY STRATUM
  RATE.DELAY                         1      0.2025       0.01      0.2025      0.148
  RATE.DELAY.NOISE                   1      0.0625       0.00      0.0625      0.046
  RESIDUAL                          18     24.6100       1.72      1.3672      3.574
TOTAL                               20     24.8750       1.74      1.2438      3.251

SUBJ.ARTIC.CONFUSIO STRATUM
  ARTIC.CONFUSIO                     1      1.2100       0.08      1.2100      1.718
  ARTIC.CONFUSIO.NOISE               1      0.0900       0.01      0.0900      0.128
  RESIDUAL                          18     12.6750       0.89      0.7042      1.841
TOTAL                               20     13.9750       0.98      0.6988      1.827

SUBJ.RATE.CONFUSIO STRATUM
  RATE.CONFUSIO                      1      7.5625       0.53      7.5625      4.254
  RATE.CONFUSIO.NOISE                1      1.5625       0.11      1.5625      0.879
  RESIDUAL                          18     32.0000       2.24      1.7778      4.647
TOTAL                               20     41.1250       2.87      2.0562      5.375

SUBJ.DELAY.CONFUSIO STRATUM
  DELAY.CONFUSIO                     1      1.3225       0.09      1.3225      1.708
  DELAY.CONFUSIO.NOISE               1      0.5625       0.04      0.5625      0.726
  RESIDUAL                          18     13.9400       0.97      0.7744      2.025
TOTAL                               20     15.8250       1.11      0.7913      2.068

SUBJ.ARTIC.POSITION STRATUM
  ARTIC.POSITION                     4      3.8162       0.27      0.9541      2.643
  ARTIC.POSITION.NOISE               4      0.9162       0.06      0.2291      0.635
  RESIDUAL                          72     25.9925       1.82      0.3610      0.944
TOTAL                               80     30.7250       2.15      0.3841      1.004

SUBJ.RATE.POSITION STRATUM
  RATE.POSITION                      4     14.6087       1.02      3.6522      5.427
  RATE.POSITION.NOISE                4      2.6087       0.18      0.6522      0.969
  RESIDUAL                          72     48.4575       3.38      0.6730      1.759
TOTAL                               80     65.6750       4.59      0.8209      2.146

SUBJ.DELAY.POSITION STRATUM
  DELAY.POSITION                     4      4.5537       0.32      1.1384      3.843
  DELAY.POSITION.NOISE               4      3.0937       0.22      0.7734      2.611
  RESIDUAL                          72     21.3275       1.49      0.2962      0.774
TOTAL                               80     28.9750       2.02      0.3622      0.947

SUBJ.CONFUSIO.POSITION STRATUM
  CONFUSIO.POSITION                  4     17.3787       1.21      4.3447     10.979
```

```
  CONFUSIO.POSITION.NOISE                     4      1.3537      0.09      0.3384     0.855
  RESIDUAL                                   72     28.4925      1.99      0.3957     1.034
TOTAL                                        80     47.2250      3.30      0.5903     1.543

SUBJ.ARTIC.RATE.DELAY STRATUM
  ARTIC.RATE.DELAY                            1      4.0000      0.28      4.0000     3.585
  ARTIC.RATE.DELAY.NOISE                      1      0.0900      0.01      0.0900     0.081
  RESIDUAL                                   18     20.0850      1.40      1.1158     2.917
TOTAL                                        20     24.1750      1.69      1.2088     3.160

SUBJ.ARTIC.RATE.CONFUSIO STRATUM
  ARTIC.RATE.CONFUSIO                         1      1.6900      0.12      1.6900     1.726
  ARTIC.RATE.CONFUSIO.NOISE                   1      1.2100      0.08      1.2100     1.236
  RESIDUAL                                   18     17.6250      1.23      0.9792     2.560
TOTAL                                        20     20.5250      1.43      1.0262     2.683

SUBJ.ARTIC.DELAY.CONFUSIO STRATUM
  ARTIC.DELAY.CONFUSIO                        1      0.3600      0.03      0.3600     0.601
  ARTIC.DELAY.CONFUSIO.NOISE                  1      0.4900      0.03      0.4900     0.819
  RESIDUAL                                   18     10.7750      0.75      0.5986     1.565
TOTAL                                        20     11.6250      0.81      0.5812     1.519

SUBJ.RATE.DELAY.CONFUSIO STRATUM
  RATE.DELAY.CONFUSIO                         1      0.7225      0.05      0.7225     1.063
  RATE.DELAY.CONFUSIO.NOISE                   1      0.4225      0.03      0.4225     0.622
  RESIDUAL                                   18     12.2300      0.85      0.6794     1.776
TOTAL                                        20     13.3750      0.93      0.6687     1.748

SUBJ.ARTIC.RATE.POSITION STRATUM
  ARTIC.RATE.POSITION                         4      1.1962      0.08      0.2991     0.803
  ARTIC.RATE.POSITION.NOISE                   4      1.5213      0.11      0.3803     1.021
  RESIDUAL                                   72     26.8075      1.87      0.3723     0.973
TOTAL                                        80     29.5250      2.06      0.3691     0.965

SUBJ.ARTIC.DELAY.POSITION STRATUM
  ARTIC.DELAY.POSITION                        4      1.6212      0.11      0.4053     1.133
  ARTIC.DELAY.POSITION.NOISE                  4      1.0562      0.07      0.2641     0.738
  RESIDUAL                                   72     25.7475      1.80      0.3576     0.935
TOTAL                                        80     28.4250      1.99      0.3553     0.929

SUBJ.RATE.DELAY.POSITION STRATUM
  RATE.DELAY.POSITION                         4      0.6287      0.04      0.1572     0.518
  RATE.DELAY.POSITION.NOISE                   4      0.3937      0.03      0.0984     0.324
  RESIDUAL                                   72     21.8525      1.53      0.3035     0.793
TOTAL                                        80     22.8750      1.60      0.2859     0.747

SUBJ.ARTIC.CONFUSIO.POSITION STRATUM
  ARTIC.CONFUSIO.POSITION                     4      4.2962      0.30      1.0741     3.864
  ARTIC.CONFUSIO.POSITION.NOISE
                                              4      0.9663      0.07      0.2416     0.869
  RESIDUAL                                   72     20.0125      1.40      0.2780     0.727
TOTAL                                        80     25.2750      1.77      0.3159     0.826

SUBJ.RATE.CONFUSIO.POSITION STRATUM
  RATE.CONFUSIO.POSITION                      4      2.2687      0.16      0.5672     1.918
  RATE.CONFUSIO.POSITION.NOISE
                                              4      1.5688      0.11      0.3922     1.326
  RESIDUAL                                   72     21.2875      1.49      0.2957     0.773
TOTAL                                        80     25.1250      1.75      0.3141     0.821

SUBJ.DELAY.CONFUSIO.POSITION STRATUM
  DELAY.CONFUSIO.POSITION                     4      0.0837      0.01      0.0209     0.066
  DELAY.CONFUSIO.POSITION.NOISE
                                              4      0.6438      0.04      0.1609     0.511
  RESIDUAL                                   72     22.6975      1.59      0.3152     0.824
TOTAL                                        80     23.4250      1.64      0.2928     0.765

SUBJ.ARTIC.RATE.DELAY.CONFUSIO STRATUM
  ARTIC.RATE.DELAY.CONFUSIO                   1      3.2400      0.23      3.2400     3.046
  ARTIC.RATE.DELAY.CONFUSIO.NOISE
                                              1      0.4900      0.03      0.4900     0.461
  RESIDUAL                                   18     19.1450      1.34      1.0636     2.780
TOTAL                                        20     22.8750      1.60      1.1437     2.990

SUBJ.ARTIC.RATE.DELAY.POSITION STRATUM
  ARTIC.RATE.DELAY.POSITION                   4      1.1062      0.08      0.2766     0.926
  ARTIC.RATE.DELAY.POSITION.NOISE
                                              4      0.2162      0.02      0.0541     0.181
  RESIDUAL                                   72     21.5025      1.50      0.2986     0.781
TOTAL                                        80     22.8250      1.59      0.2853     0.746

SUBJ.ARTIC.RATE.CONFUSIO.POSITION STRATUM
  ARTIC.RATE.CONFUSIO.POSITION
                                              4      2.0162      0.14      0.5041     1.394
  ARTIC.RATE.CONFUSIO.POSITION.NOISE
                                              4      0.4212      0.03      0.1053     0.291
  RESIDUAL                                   72     26.0375      1.82      0.3616     0.945
TOTAL                                        80     28.4750      1.99      0.3559     0.930

SUBJ.ARTIC.DELAY.CONFUSIO.POSITION STRATUM
  ARTIC.DELAY.CONFUSIO.POSITION
                                              4      1.4212      0.10      0.3553     0.838
  ARTIC.DELAY.CONFUSIO.POSITION.NOISE
                                              4      1.4162      0.10      0.3541     0.835
  RESIDUAL                                   72     30.5375      2.13      0.4241     1.109
TOTAL                                        80     33.3750      2.33      0.4172     1.091
```

```
SUBJ.RATE.DELAY.CONFUSIO.POSITION STRATUM
  RATE.DELAY.CONFUSIO.POSITION
                                   4      1.6587      0.12      0.4147     1.100
  RATE.DELAY.CONFUSIO.POSITION.NOISE
                                   4      3.3337      0.23      0.8334     2.212
  RESIDUAL                        72     27.1325      1.90      0.3768     0.985
TOTAL                             80     32.1250      2.24      0.4016     1.050

SUBJ.ARTIC.RATE.DELAY.CONFUSIO.POSITION STRATUM
  ARTIC.RATE.DELAY.CONFUSIO.POSITION
                                   4      0.7662      0.05      0.1916     0.501
  ARTIC.RATE.DELAY.CONFUSIO.POSITION.NOISE
                                   4      1.0662      0.07      0.2666     0.697
  RESIDUAL                        72     27.5425      1.92      0.3825
TOTAL                             80     29.3750      2.05      0.3672

GRAND TOTAL                     1599   1431.6775    100.00
```

```
***** ANALYSIS OF VARIANCE *****EXPERIMENT 4

SOURCE OF VARIATION                DF        SS        SS:          MS         VR

SUBJ STRATUM
  NOISE                             1     10.5625      0.66     10.5625      1.109
  RESIDUAL                         18    171.4025     10.72      9.5224     23.114
TOTAL                              19    181.9650     11.38      9.5771     23.247

SUBJ.ARTIC STRATUM
  ARTIC                             1      9.0000      0.56      9.0000      7.605
  ARTIC.NOISE                       1      0.4225      0.03      0.4225      0.357
  RESIDUAL                         18     21.[illegible]025      1.33      1.1835      2.873
TOTAL                              20     30.7250      1.92      1.5362      3.729

SUBJ.RATE STRATUM
  RATE                              1     68.0625      4.26     68.0625     26.859
  RATE.NOISE                        1      2.2500      0.14      2.2500      0.888
  RESIDUAL                         18     45.6125      2.85      2.5340      6.151
TOTAL                              20    115.9250      7.25      5.7963     14.069

SUBJ.DELAY STRATUM
  DELAY                             1      0.1225      0.01      0.1225      0.221
  DELAY.NOISE                       1      2.5600      0.16      2.5600      4.611
  RESIDUAL                         18      9.9925      0.62      0.5551      1.347
TOTAL                              20     12.6750      0.79      0.6338      1.538

SUBJ.CONFUSIO STRATUM
  CONFUSIO                          1    171.6100     10.73    171.6100    101.569
  CONFUSIO.NOISE                    1      1.1025      0.07      1.1025      0.653
  RESIDUAL                         18     30.4125      1.90      1.6896      4.101
TOTAL                              20    203.1250     12.70     10.1562     24.652

SUBJ.POSITION STRATUM
  POSITION                          4    153.9400      9.63     38.4850     66.733
  POSITION.NOISE                    4      2.1375      0.13      0.5344      0.927
  RESIDUAL                         72     41.5225      2.60      0.5767      1.400
TOTAL                              80    197.6000     12.36      2.4700      5.995

SUBJ.ARTIC.RATE STRATUM
  ARTIC.RATE                        1      0.0225      0.00      0.0225      0.014
  ARTIC.RATE.NOISE                  1      1.2100      0.08      1.2100      0.735
  RESIDUAL                         18     29.6425      1.85      1.6468      3.997
TOTAL                              20     30.8750      1.93      1.5437      3.747

SUBJ.ARTIC.DELAY STRATUM
  ARTIC.DELAY                       1      2.7225      0.17      2.7225      2.383
  ARTIC.DELAY.NOISE                 1      3.2400      0.20      3.2400      2.836
  RESIDUAL                         18     20.5625      1.29      1.1424      2.773
TOTAL                              20     26.5250      1.66      1.3262      3.219

SUBJ.RATE.DELAY STRATUM
  RATE.DELAY                        1      0.6400      0.04      0.6400      0.504
  RATE.DELAY.NOISE                  1      0.7225      0.05      0.7225      0.569
  RESIDUAL                         18     22.8625      1.43      1.2701      3.083
TOTAL                              20     24.2250      1.51      1.2112      2.940

SUBJ.ARTIC.CONFUSIO STRATUM
  ARTIC.CONFUSIO                    1      0.0400      0.00      0.0400      0.023
  ARTIC.CONFUSIO.NOISE              1      1.5625      0.10      1.5625      0.885
  RESIDUAL                         18     31.7725      1.99      1.7651      4.285
TOTAL                              20     33.3750      2.09      1.6687      4.051

SUBJ.RATE.CONFUSIO STRATUM
  RATE.CONFUSIO                     1     20.7025      1.29     20.7025      9.325
  RATE.CONFUSIO.NOISE               1      0.0100      0.00      0.0100      0.005
  RESIDUAL                         18     39.9625      2.50      2.2201      5.389
TOTAL                              20     60.6750      3.79      3.0337      7.364

SUBJ.DELAY.CONFUSIO STRATUM
  DELAY.CONFUSIO                    1      0.4225      0.03      0.4225      0.283
  DELAY.CONFUSIO.NOISE              1      0.8100      0.05      0.8100      0.542
  RESIDUAL                         18     26.8925      1.68      1.4940      3.626
TOTAL                              20     28.1250      1.76      1.4062      3.413

SUBJ.ARTIC.POSITION STRATUM
  ARTIC.POSITION                    4      3.3000      0.21      0.8250      2.125
  ARTIC.POSITION.NOISE              4      0.1525      0.01      0.0381      0.098
  RESIDUAL                         72     27.9475      1.75      0.3882      0.942
TOTAL                              80     31.4000      1.96      0.3925      0.953

SUBJ.RATE.POSITION STRATUM
  RATE.POSITION                     4      9.7875      0.61      2.4469      5.195
  RATE.POSITION.NOISE               4      0.5000      0.03      0.1250      0.265
  RESIDUAL                         72     33.9125      2.12      0.4710      1.143
TOTAL                              80     44.2000      2.76      0.5525      1.341

SUBJ.DELAY.POSITION STRATUM
  DELAY.POSITION                    4      1.5400      0.10      0.3850      1.064
  DELAY.POSITION.NOISE              4      1.3525      0.08      0.3381      0.934
  RESIDUAL                         72     26.0575      1.63      0.3619      0.878
TOTAL                              80     28.9500      1.81      0.3619      0.878

SUBJ.CONFUSIO.POSITION STRATUM
  CONFUSIO.POSITION                 4     17.0650      1.07      4.2663     10.754
```

```
  CONFUSIO.POSITION.NOISE              4     1.6225       0.10       0.4056      1.022
  RESIDUAL                            72    28.5625       1.79       0.3967      0.963
TOTAL                                 80    47.2500       2.95       0.5906      1.434

SUBJ.ARTIC.RATE.DELAY STRATUM
  ARTIC.RATE.DELAY                     1     0.0900       0.01       0.0900      0.066
  ARTIC.RATE.DELAY.NOISE               1     0.0625       0.00       0.0625      0.046
  RESIDUAL                            18    24.7225       1.55       1.3735      3.334
TOTAL                                 20    24.8750       1.56       1.2438      3.019

SUBJ.ARTIC.RATE.CONFUSIO STRATUM
  ARTIC.RATE.CONFUSIO                  1     0.4225       0.03       0.4225      0.392
  ARTIC.RATE.CONFUSIO.NOISE            1     5.2900       0.33       5.2900      4.905
  RESIDUAL                            18    19.4125       1.21       1.0785      2.618
TOTAL                                 20    25.1250       1.57       1.2562      3.049

SUBJ.ARTIC.DELAY.CONFUSIO STRATUM
  ARTIC.DELAY.CONFUSIO                 1     0.1225       0.01       0.1225      0.111
  ARTIC.DELAY.CONFUSIO.NOISE           1     1.6900       0.11       1.6900      1.532
  RESIDUAL                            18    19.8625       1.24       1.1035      2.678
TOTAL                                 20    21.6750       1.36       1.0837      2.631

SUBJ.RATE.DELAY.CONFUSIO STRATUM
  RATE.DELAY.CONFUSIO                  1     0.0900       0.01       0.0900      0.053
  RATE.DELAY.CONFUSIO.NOISE            1     0.0625       0.00       0.0625      0.037
  RESIDUAL                            18    30.3225       1.90       1.6846      4.089
TOTAL                                 20    30.4750       1.91       1.5237      3.699

SUBJ.ARTIC.RATE.POSITION STRATUM
  ARTIC.RATE.POSITION                  4     3.7775       0.24       0.9444      2.179
  ARTIC.RATE.POSITION.NOISE            4     1.0150       0.06       0.2537      0.585
  RESIDUAL                            72    31.2075       1.95       0.4334      1.052
TOTAL                                 80    36.0000       2.25       0.4500      1.092

SUBJ.ARTIC.DELAY.POSITION STRATUM
  ARTIC.DELAY.POSITION                 4     0.7400       0.05       0.1850      0.459
  ARTIC.DELAY.POSITION.NOISE           4     3.0975       0.19       0.7744      1.922
  RESIDUAL                            72    29.0125       1.81       0.4030      0.978
TOTAL                                 80    32.8500       2.05       0.4106      0.997

SUBJ.RATE.DELAY.POSITION STRATUM
  RATE.DELAY.POSITION                  4     0.3975       0.02       0.0994      0.250
  RATE.DELAY.POSITION.NOISE            4     0.6650       0.04       0.1663      0.419
  RESIDUAL                            72    28.5875       1.79       0.3970      0.964
TOTAL                                 80    29.6500       1.85       0.3706      0.900

SUBJ.ARTIC.CONFUSIO.POSITION STRATUM
  ARTIC.CONFUSIO.POSITION              4     1.5350       0.10       0.3838      0.830
  ARTIC.CONFUSIO.POSITION.NOISE
                                       4     1.9375       0.12       0.4844      1.048
  RESIDUAL                            72    33.2775       2.08       0.4622      1.122
TOTAL                                 80    36.7500       2.30       0.4594      1.115

SUBJ.RATE.CONFUSIO.POSITION STRATUM
  RATE.CONFUSIO.POSITION               4     4.9475       0.31       1.2369      2.714
  RATE.CONFUSIO.POSITION.NOISE
                                       4     0.1900       0.01       0.0475      0.104
  RESIDUAL                            72    32.8125       2.05       0.4557      1.106
TOTAL                                 80    37.9500       2.37       0.4744      1.151

SUBJ.DELAY.CONFUSIO.POSITION STRATUM
  DELAY.CONFUSIO.POSITION              4     0.7150       0.04       0.1787      0.597
  DELAY.CONFUSIO.POSITION.NOISE
                                       4     1.2275       0.08       0.3069      1.025
  RESIDUAL                            72    21.5575       1.35       0.2994      0.727
TOTAL                                 80    23.5000       1.47       0.2937      0.713

SUBJ.ARTIC.RATE.DELAY.CONFUSIO STRATUM
  ARTIC.RATE.DELAY.CONFUSIO            1     3.2400       0.20       3.2400      2.717
  ARTIC.RATE.DELAY.CONFUSIO.NOISE
                                       1     0.1225       0.01       0.1225      0.103
  RESIDUAL                            18    21.4625       1.34       1.1924      2.894
TOTAL                                 20    24.8250       1.55       1.2412      3.013

SUBJ.ARTIC.RATE.DELAY.POSITION STRATUM
  ARTIC.RATE.DELAY.POSITION            4     2.1475       0.13       0.5369      1.135
  ARTIC.RATE.DELAY.POSITION.NOISE
                                       4     0.5500       0.03       0.1375      0.291
  RESIDUAL                            72    34 0525       2.13       0.4730      1.148
TOTAL                                 80    36.7500       2.30       0.4594      1.115

SUBJ.ARTIC.RATE.CONFUSIO.POSITION STRATUM
  ARTIC.RATE.CONFUSIO.POSITION
                                       4     2.9775       0.19       0.7444      2.277
  ARTIC.RATE.CONFUSIO.POSITION.NOISE
                                       4     2.7350       0.17       0.6837      2.092
  RESIDUAL                            72    23.5375       1.47       0.3269      0.794
TOTAL                                 80    29.2500       1.83       0.3656      0.887

SUBJ.ARTIC.DELAY.CONFUSIO.POSITION STRATUM
  ARTIC.DELAY.CONFUSIO.POSITION
                                       4     6.0650       0.38       1.5162      3.262
  ARTIC.DELAY.CONFUSIO.POSITION.NOISE
                                       4     3.1725       0.20       0.7931      1.707
  RESIDUAL                            72    33.4625       2.09       0.4648      1.128
TOTAL                                 80    42.7000       2.67       0.5337      1.296
```

```
SUBJ.RATE.DELAY.CONFUSIO.POSITION STRATUM
  RATE.DELAY.CONFUSIO.POSITION
                                 4     1.7475      0.11       0.4369      0.947
  RATE.DELAY.CONFUSIO.POSITION.NOISE
                                 4     0.9250      0.06       0.2312      0.501
  RESIDUAL                      72    33.2275      2.08       0.4615      1.120
TOTAL                           80    35.9000      2.24       0.4487      1.089

SUBJ.ARTIC.RATE.DELAY.CONFUSIO.POSITION STRATUM
  ARTIC.RATE.DELAY.CONFUSIO.POSITION
                                 4     3.0975      0.19       0.7744      1.880
  ARTIC.RATE.DELAY.CONFUSIO.POSITION.NOISE
                                 4     0.5400      0.03       0.1350      0.328
  RESIDUAL                      72    29.6625      1.85       0.4120
TOTAL                           80    33.3000      2.08       0.4163

GRAND TOTAL                   1599  1599.1900    100.00
```

ANALYSIS OF VARIANCE EXPERIMENT 6 Recall Data

SOURCE OF VARIATION	D.F.	S.S	M.S	VR
Between conditions	2	5.06	2.53	0.16
Error	49	761.63	15.54	
Total	51	766.69		

ANALYSIS OF VARIANCE EXPT. 6 Recognition Data

SOURCE OF VARIATION	D.F.	S.S	M.S	VR
Between conditions	2	21.9	10.95	0.70
Error	49	766.62	15.65	
Total	51	788.52		

ANALYSIS OF VARIANCE EXPT. 6 β scores

SOURCE OF VARIATION	D.F.	S.S	M.S	VR
Between conditions	2	114.80	57.4	3.05
Linear component	1	45.10	45.10	2.39
Error	48	905.13	18.86	
Total	50	1019.93		

```
***** ANALYSIS OF VARIANCE *****EXPERIMENT 7

SOURCE OF VARIATION                DF(MV)          SS        SS:          MS         VR

SUBJ STRATUM                         10       1992246      66.89      199225    159.772

SUBJ.NOISE STRATUM
  NOISE                               1         31042       1.04       31042      1.579
  RESIDUAL                           10        196582       6.60       19658     15.765
TOTAL                                11        227625       7.64       20693     16.595

SUBJ.TASK STRATUM
  TASK                                1          4926       0.17        4926      0.620
  RESIDUAL                           10         79486       2.67        7949      6.375
TOTAL                                11         84413       2.83        7674      6.154

SUBJ.CONFUSIO STRATUM
  CONFUSIO                            1         71241       2.39       71241     10.319
  RESIDUAL                           10         69042       2.32        6904      5.537
TOTAL                                11        140283       4.71       12753     10.227

SUBJ.NOISE.TASK STRATUM
  NOISE.TASK                          1         37375       1.25       37375      3.278
  RESIDUAL                           10        114032       3.83       11403      9.145
TOTAL                                11        151407       5.08       13764     11.038

SUBJ.NOISE.CONFUSIO STRATUM
  NOISE.CONFUSIO                      1          1121       0.04        1121      3.260
  RESIDUAL                           10          3438       0.12         344      0.276
TOTAL                                11          4559       0.15         414      0.332

SUBJ.TASK.CONFUSIO STRATUM
  TASK.CONFUSIO                       1           165       0.01         165      0.298
  RESIDUAL                           10          5522       0.19         552      0.443
TOTAL                                11          5687       0.19         517      0.415

SUBJ.NOISE.TASK.CONFUSIO STRATUM
  NOISE.TASK.CONFUSIO                 1          2398       0.08        2398      6.500
  RESIDUAL                           10          3689       0.12         369      0.296
TOTAL                                11          6088       0.20         553      0.444

SUBJ.NOISE.TASK.CONFUSIO.*UNITS* STRATUM
                                 343( 9)       427698      14.36        1247

GRAND TOTAL                         430       3040004     102.07
```

```
***** ANALYSIS OF VARIANCE *****EXPERIMENT 8  SINGLE WORD  DATA

SOURCE OF VARIATION                  DF         SS        SS:          MS         VR

SUBJ STRATUM                          9   30492.41      61.26     3388.05    205.327

SUBJ.NOISE STRATUM
  NOISE                               1       2.76       0.01        2.76      0.011
  RESIDUAL                            9    2203.56       4.43      244.84     14.838
TOTAL                                10    2206.31       4.43      220.63     13.371

SUBJ.SYL STRATUM
  SYL                                 1    6592.06      13.24     6592.06     33.786
  RESIDUAL                            9    1756.01       3.53      195.11     11.824
TOTAL                                10    8348.06      16.77      834.81     50.592

SUBJ.LEN STRATUM
  LEN                                 1    4378.56       8.80     4378.56     63.946
  RESIDUAL                            9     616.26       1.24       68.47      4.150
TOTAL                                10    4994.81      10.03      499.48     30.270

SUBJ.CONF STRATUM
  CONF                                1      35.16       0.07       35.16      0.754
  RESIDUAL                            9     419.41       0.84       46.60      2.824
TOTAL                                10     454.56       0.91       45.46      2.755

SUBJ.NOISE.SYL STRATUM
  NOISE.SYL                           1       0.16       0.00        0.16      0.009
  RESIDUAL                            9     149.66       0.30       16.63      1.008
TOTAL                                10     149.81       0.30       14.98      0.908

SUBJ.NOISE.LEN STRATUM
  NOISE.LEN                           1       0.06       0.00        0.06      0.001
  RESIDUAL                            9     406.01       0.82       45.11      2.734
TOTAL                                10     406.06       0.82       40.61      2.461

SUBJ.SYL.LEN STRATUM
  SYL.LEN                             1      51.76       0.10       51.76      1.034
  RESIDUAL                            9     450.56       0.91       50.06      3.034
TOTAL                                10     502.31       1.01       50.23      3.044

SUBJ.NOISE.CONF STRATUM
  NOISE.CONF                          1      31.51       0.06       31.51      1.218
  RESIDUAL                            9     232.81       0.47       25.87      1.568
TOTAL                                10     264.31       0.53       26.43      1.602

SUBJ.SYL.CONF STRATUM
  SYL.CONF                            1      91.51       0.18       91.51      3.280
  RESIDUAL                            9     251.06       0.50       27.90      1.691
TOTAL                                10     342.56       0.69       34.26      2.076

SUBJ.LEN.CONF STRATUM
  LEN.CONF                            1     369.06       0.74      369.06     18.845
  RESIDUAL                            9     176.26       0.35       19.58      1.187
TOTAL                                10     545.31       1.10       54.53      3.305

SUBJ.NOISE.SYL.LEN STRATUM
  NOISE.SYL.LEN                       1       2.26       0.00        2.26      0.073
  RESIDUAL                            9     276.81       0.56       30.76      1.864
TOTAL                                10     279.06       0.56       27.91      1.691

SUBJ.NOISE.SYL.CONF STRATUM
  NOISE.SYL.CONF                      1      37.06       0.07       37.06      1.670
  RESIDUAL                            9     199.76       0.40       22.20      1.345
TOTAL                                10     236.81       0.48       23.68      1.435

SUBJ.NOISE.LEN.CONF STRATUM
  NOISE.LEN.CONF                      1      31.51       0.06       31.51      1.246
  RESIDUAL                            9     227.56       0.46       25.28      1.532
TOTAL                                10     259.06       0.52       25.91      1.570

SUBJ.SYL.LEN.CONF STRATUM
  SYL.LEN.CONF                        1       0.31       0.00        0.31      0.021
  RESIDUAL                            9     129.51       0.26       14.39      0.872
TOTAL                                10     129.81       0.26       12.98      0.787

SUBJ.NOISE.SYL.LEN.CONF STRATUM
  NOISE.SYL.LEN.CONF                  1      17.56       0.04       17.56      1.064
  RESIDUAL                            9     148.51       0.30       16.50
TOTAL                                10     166.06       0.33       16.61

GRAND TOTAL                         159   49777.34     100.00
```

```
***** ANALYSIS OF VARIANCE ***** EXPERIMENT 8

SOURCE OF VARIATION                   DF           SS       SS:           MS        VR

SUBJ STRATUM                           9     260575.5     10.77      28952.8    72.640

SUBJ.TASK STRATUM
  TASK                                 1     107898.0      4.46     107898.0    10.454
  RESIDUAL                             9      92891.1      3.84      10321.2    25.895
TOTAL                                 10     200789.1      8.30      20078.9    50.376

SUBJ.NOISE STRATUM
  NOISE                                1      19127.1      0.79      19127.1     6.587
  RESIDUAL                             9      26134.5      1.08       2903.8     7.285
TOTAL                                 10      45261.6      1.87       4526.2    11.356

SUBJ.SYL STRATUM
  SYL                                  1     201101.5      8.31     201101.5    24.644
  RESIDUAL                             9      73443.0      3.04       8160.3    20.473
TOTAL                                 10     274544.5     11.35      27454.4    68.880

SUBJ.LEN STRATUM
  LEN                                  1     290164.1     11.99     290164.1    62.350
  RESIDUAL                             9      41884.1      1.73       4653.8    11.676
TOTAL                                 10     332048.1     13.72      33204.8    83.307

SUBJ.CONF STRATUM
  CONF                                 1     361132.8     14.93     361132.8    16.999
  RESIDUAL                             9     191197.8      7.90      21244.2    53.299
TOTAL                                 10     552330.6     22.83      55233.1   138.574

SUBJ.TASK.NOISE STRATUM
  TASK.NOISE                           1      14553.0      0.60      14553.0     4.408
  RESIDUAL                             9      29711.5      1.23       3301.3     8.283
TOTAL                                 10      44264.5      1.83       4426.5    11.105

SUBJ.TASK.SYL STRATUM
  TASK.SYL                             1         78.0      0.00         78.0     0.045
  RESIDUAL                             9      15693.6      0.65       1743.7     4.375
TOTAL                                 10      15771.6      0.65       1577.2     3.957

SUBJ.NOISE.SYL STRATUM
  NOISE.SYL                            1       1584.2      0.07       1584.2     4.861
  RESIDUAL                             9       2933.2      0.12        325.9     0.818
TOTAL                                 10       4517.4      0.19        451.7     1.133

SUBJ.TASK.LEN STRATUM
  TASK.LEN                             1      13992.1      0.58      13992.1    20.302
  RESIDUAL                             9       6202.7      0.26        689.2     1.729
TOTAL                                 10      20194.8      0.83       2019.5     5.067

SUBJ.NOISE.LEN STRATUM
  NOISE.LEN                            1        655.5      0.03        655.5     0.757
  RESIDUAL                             9       7790.0      0.32        865.6     2.172
TOTAL                                 10       8445.5      0.35        844.6     2.119

SUBJ.SYL.LEN STRATUM
  SYL.LEN                              1      92004.6      3.80      92004.6    12.760
  RESIDUAL                             9      64891.5      2.68       7210.2    18.090
TOTAL                                 10     156896.1      6.49      15689.6    39.364

SUBJ.TASK.CONF STRATUM
  TASK.CONF                            1     113627.8      4.70     113627.8    30.570
  RESIDUAL                             9      33453.2      1.38       3717.0     9.326
TOTAL                                 10     147081.0      6.08      14708.1    36.901

SUBJ.NOISE.CONF STRATUM
  NOISE.CONF                           1        180.0      0.01        180.0     0.362
  RESIDUAL                             9       4473.2      0.18        497.0     1.247
TOTAL                                 10       4653.2      0.19        465.3     1.167

SUBJ.SYL.CONF STRATUM
  SYL.CONF                             1      35448.2      1.47      35448.2     7.326
  RESIDUAL                             9      43548.2      1.80       4838.7    12.140
TOTAL                                 10      78996.4      3.27       7899.6    19.819

SUBJ.LEN.CONF STRATUM
  LEN.CONF                             1         27.6      0.00         27.6     0.005
  RESIDUAL                             9      47393.6      1.96       5266.0    13.212
TOTAL                                 10      47421.2      1.96       4742.1    11.897

SUBJ.TASK.NOISE.SYL STRATUM
  TASK.NOISE.SYL                       1       1638.1      0.07       1638.1     1.640
  RESIDUAL                             9       8991.7      0.37        999.1     2.507
TOTAL                                 10      10629.7      0.44       1063.0     2.667

SUBJ.TASK.NOISE.LEN STRATUM
  TASK.NOISE.LEN                       1       5594.5      0.23       5594.5     8.734
  RESIDUAL                             9       5764.9      0.24        640.5     1.607
TOTAL                                 10      11359.4      0.47       1135.9     2.850

SUBJ.TASK.SYL.LEN STRATUM
  TASK.SYL.LEN                         1       4515.0      0.19       4515.0     4.198
  RESIDUAL                             9       9679.2      0.40       1075.5     2.698
TOTAL                                 10      14194.3      0.59       1419.4     3.561
```

```
SUBJ.NOISE.SYL.LEN STRATUM
  NOISE.SYL.LEN                      1       649.8      0.03       649.8     0.614
  RESIDUAL                           9      9517.9      0.39      1057.5     2.653
TOTAL                               10     10167.7      0.42      1016.8     2.551

SUBJ.TASK.NOISE.CONF STRATUM
  TASK.NOISE.CONF                    1      2714.4      0.11      2714.4     2.343
  RESIDUAL                           9     10428.9      0.43      1158.8     2.907
TOTAL                               10     13143.4      0.54      1314.3     3.298

SUBJ.TASK.SYL.CONF STRATUM
  TASK.SYL.CONF                      1      2928.2      0.12      2928.2     2.439
  RESIDUAL                           9     10803.5      0.45      1200.4     3.012
TOTAL                               10     13731.7      0.57      1373.2     3.445

SUBJ.NOISE.SYL.CONF STRATUM
  NOISE.SYL.CONF                     1         0.1      0.00         0.1     0.001
  RESIDUAL                           9      1035.6      0.04       115.1     0.289
TOTAL                               10      1035.7      0.04       103.6     0.260

SUBJ.TASK.LEN.CONF STRATUM
  TASK.LEN.CONF                      1      6177.6      0.26      6177.6     7.250
  RESIDUAL                           9      7668.5      0.32       852.1     2.138
TOTAL                               10     13846.1      0.57      1384.6     3.474

SUBJ.NOISE.LEN.CONF STRATUM
  NOISE.LEN.CONF                     1        68.5      0.00        68.5     0.095
  RESIDUAL                           9      6491.2      0.27       721.2     1.810
TOTAL                               10      6559.6      0.27       656.0     1.646

SUBJ.SYL.LEN.CONF STRATUM
  SYL.LEN.CONF                       1     17346.1      0.72     17346.1     3.808
  RESIDUAL                           9     40998.0      1.69      4555.3    11.429
TOTAL                               10     58344.0      2.41      5834.4    14.638

SUBJ.TASK.NOISE.SYL.LEN STRATUM
  TASK.NOISE.SYL.LEN                 1      2442.1      0.10      2442.1     1.891
  RESIDUAL                           9     11620.1      0.48      1291.1     3.239
TOTAL                               10     14062.1      0.58      1406.2     3.528

SUBJ.TASK.NOISE.SYL.CONF STRATUM
  TASK.NOISE.SYL.CONF                1      1505.1      0.06      1505.1     0.920
  RESIDUAL                           9     14719.8      0.61      1635.5     4.103
TOTAL                               10     16224.9      0.67      1622.5     4.071

SUBJ.TASK.NOISE.LEN.CONF STRATUM
  TASK.NOISE.LEN.CONF                1       720.0      0.03       720.0     0.892
  RESIDUAL                           9      7266.3      0.30       807.4     2.026
TOTAL                               10      7986.3      0.33       798.6     2.004

SUBJ.TASK.SYL.LEN.CONF STRATUM
  TASK.SYL.LEN.CONF                  1      8694.4      0.36      8694.4     6.672
  RESIDUAL                           9     11728.4      0.48      1303.2     3.269
TOTAL                               10     20422.9      0.84      2042.3     5.124

SUBJ.NOISE.SYL.LEN.CONF STRATUM
  NOISE.SYL.LEN.CONF                 1        25.3      0.00        25.3     0.023
  RESIDUAL                           9      9890.3      0.41      1098.9     2.757
TOTAL                               10      9915.6      0.41       991.6     2.488

SUBJ.TASK.NOISE.SYL.LEN.CONF STRATUM
  TASK.NOISE.SYL.LEN.CONF            1       316.0      0.01       316.0     0.793
  RESIDUAL                           9      3587.2      0.15       398.6
TOTAL                               10      3903.3      0.16       390.3

GRAND TOTAL                        319   2419318.0    100.00
```

```
***** ANALYSIS OF VARIANCE ***** EXPERIMENT 9


SOURCE OF VARIATION              DF         SS       SS:         MS        VR

SUBJ STRATUM
  NOISE                           1    13.3225      1.57    13.3225     2.518
  RESIDUAL                       38   201.0550     23.71     5.2909     8.710
TOTAL                            39   214.3775     25.28     5.4969     9.049

SUBJ.LENGTH STRATUM
  LENGTH                          1     6.0025      0.71     6.0025     5.661
  LENGTH.NOISE                    1     2.4025      0.28     2.4025     2.266
  RESIDUAL                       38    40.2950      4.75     1.0604     1.746
TOTAL                            40    48.7000      5.74     1.2175     2.004

SUBJ.POSITION STRATUM
  POSITION                        4   292.5650     34.51    73.1413    59.878
  POSITION.NOISE                  4     0.7650      0.09     0.1912     0.157
  RESIDUAL                      152   185.6700     21.90     1.2215     2.011
TOTAL                           160   479.0000     56.49     2.9938     4.929

SUBJ.LENGTH.POSITION STRATUM
  LENGTH.POSITION                 4     3.2350      0.38     0.8087     1.331
  LENGTH.POSITION.NOISE           4    10.2350      1.21     2.5587     4.212
  RESIDUAL                      152    92.3300     10.89     0.6074
TOTAL                           160   105.8000     12.48     0.6613

GRAND TOTAL                     399   847.8775    100.00
```

```
***** ANALYSIS OF VARIANCE *****POST HOC ANALYSIS  EXPERIMENT 9

SOURCE OF VARIATION                 DF          SS         SS:          MS          VR

SUBJ STRATUM
  NOISE                              1     13.3225        1.57     13.3225       2.518
  RESIDUAL                          38    201.0550       23.71      5.2909       8.710
TOTAL                               39    214.3775       25.28      5.4969       9.049

SUBJ.LENGTH STRATUM
  LENGTH                             1      6.0025        0.71      6.0025       5.661
  LENGTH.NOISE                       1      2.4025        0.28      2.4025       2.266
  RESIDUAL                          38     40.2950        4.75      1.0604       1.746
TOTAL                               40     48.7000        5.74      1.2175       2.004

SUBJ.POSITION STRATUM
  POSITION                           4    292.5650       34.51     73.1413      59.878
    REG1                             1     42.4004        5.00     42.4004      34.711
    REG2                             1    229.6333       27.08    229.6333     187.991
    DEVIATIONS                       2     20.5313        2.42     10.2656       8.404
  POSITION.NOISE                     4      0.7650        0.09      0.1912       0.157
    REG1.DEV                         1      0.1837        0.02      0.1837       0.150
    REG2.DEV                         1      0.3000        0.04      0.3000       0.246
    DEVIATIONS                       2      0.2812        0.03      0.1406       0.115
  RESIDUAL                         152    185.6700       21.90      1.2215       2.011
TOTAL                              160    479.0000       56.49      2.9938       4.929

SUBJ.LENGTH.POSITION STRATUM
  LENGTH.POSITION                    4      3.2350        0.38      0.8087       1.331
    DEV.REG1                         1      2.4704        0.29      2.4704       4.067
    DEV.REG2                         1      0.1333        0.02      0.1333       0.220
    DEVIATIONS                       2      0.6313        0.07      0.3156       0.520
  LENGTH.POSITION.NOISE              4     10.2350        1.21      2.5587       4.212
    DEV.REG1.DEV                     1      8.5204        1.00      8.5204      14.027
    DEV.REG2.DEV                     1      1.6333        0.19      1.6333       2.689
    DEVIATIONS                       2      0.0813        0.01      0.0406       0.067
  RESIDUAL                         152     92.3300       10.89      0.6074
TOTAL                              160    105.8000       12.48      0.6613

GRAND TOTAL                        399    847.8775      100.00
```

```
***** ANALYSIS OF VARIANCE *****EXPERIMENT 10

SOURCE OF VARIATION               DF         SS        SS:          MS         VR

SUBJ STRATUM
  NOISE                            1    2790.04      13.08     2790.04      9.193
  RESIDUAL                        34   10318.62      48.39      303.49     24.380
TOTAL                             35   13108.66      61.47      374.53     30.087

SUBJ.TASK STRATUM
  TASK                             1    4363.15      20.46     4363.15    140.637
  TASK.NOISE                       1     187.39       0.88      187.39      6.040
  RESIDUAL                        34    1054.83       4.95       31.02      2.492
TOTAL                             36    5605.37      26.29      155.70     12.508

SUBJ.RESPONSE STRATUM
  RESPONSE                         1    1728.83       8.11     1728.83    171.881
  RESPONSE.NOISE                   1       3.23       0.02        3.23      0.321
  RESIDUAL                        34     341.98       1.60       10.06      0.808
TOTAL                             36    2074.04       9.73       57.61      4.628

SUBJ.TASK.RESPONSE STRATUM
  TASK.RESPONSE                    1     106.14       0.50      106.14      8.526
  TASK.RESPONSE.NOISE              1       7.76       0.04        7.76      0.623
  RESIDUAL                        34     423.25       1.98       12.45
TOTAL                             36     537.15       2.52       14.92

GRAND TOTAL                      143   21325.22     100.00
```

References

ARCHER, B. U. & MARGOLIN, R. (1970) Arousal effects in intentional recall and forgetting. J. Exp. Psychol. 86, 8-12.

BADDELEY, A. D. (1966) Short term memory for word sequences as a function of acoustic, semantic and formal similarity. Quart. J. Exp. Psychol. 18, 362-365

BADDELEY, A. D. (1968) How does acoustic similarity influence short term memory? Quart. J. Exp. Psychol. 20, 249-264

BADDELEY, A. D. (1976) The psychology of memory. Basic Books. N. Y. Harper.

BADDELEY, A., ELRIDGE, M., & LEWIS, V. (1981) The role of subvocalization in reading. Quart. J. Exp. Psychol. 33A, 439-454

BADDELEY, A. D., HATTER, J.E., SCOTT, D. & SNASHALL, A. (1970) Memory and time of day. Quart. J. Exp. Psychol. 22, 605-609

BADDELEY, A. D. & HITCH, G. (1974) Working memory. In G. H. Bower (Ed) Recent Advances In Learning and Motivation, Vol. VIII, 47-89

BADDELEY, A. & LEWIS, V. (1981) Inner active processes in reading: The inner voice, the inner ear and the inner eye. In A. M. Lesgold & Perfetti, C. A. (Eds.) Interactive Processes in Reading. Hillsdale. N. J. Erlbaum.

BADDELEY, A. D., THOMSON, N & BUCHANAN, M. (1975) Word length and the structure of short-term memory. J. verb. Learn. verb. Behav. 14, 575-589

BARLOW, S. M. & ABBS, J. H. (1978) Some evidence of auditory feedback contributions to the ongoing control of speech production. A. S. H. A. 20, 9, 728 (Sept. 1978)

BARON, J. (1977) Mechanisms for pronouncing printed words: use and acquisition. In Laberge, D. & Samuels, S. J. (Eds.) Basic processes in reading: Perception and Comprehension. Hillsdale. N. J. Erlbaum.

BATTIG, W. F. & MONTAGUE, W. (1969) Category norms for verbal items in 56 categories: A replication and extension of the Connecticut Category norms. J. Exp. Psychol. Monogr. 80. No. 3

BERLYNE, D. E., BORSA, D. M., CRAW, M. A., GELMAN, R. S. & MANDELL, E. E. (1965) Effects of stimulus complexity and induced arousal on paired-associate learning. J. verb. Learn. verb. Behav. 4, 291-299

BERLYNE, D. E., BORSA, D. M., HAMACHER, J. H. & KOENIG, I. D. V. (1966) Paired associate learning and timing of arousal. J. Exp. Psychol. 72, 1-6.

BESNER, D. & COLTHEART, M (1979) Ideographic and alphabetic processing in skilled reading of English. Neuropsychologia 17, 467-472.

BESNER, D., DAVIES, J. & DANIELS, S. (1981) Reading for meaning : the effects of concurrent articulation. Quart. J. Exp. Psychol. 33A. 415-437

BLAIR, F. X. (1957) A study of the visual memory of deaf and hearing children. American Annals of the Deaf. 102 254-263.

BLAKE, M. J. F. (1967) Relationships between circadian rhythm of body temperature and introversion-extraversion. Nature. Lond. 215, 896-897

BREEN- LEWIS, E. K. & WILDING, J. (in press) Noise, time of day and test expectations in recall and recognition.

BROADBENT, D. E. (1971) Decision and Stress. Academic Press, London.

BROADBENT, D. E. (1978) The current status of noise research: A reply to Poulton. Psychol. Bull. 85, 1052-1067

BROWN, J. (1976) Recognition and Recall. Wiley, London.

CHASE, W. G. (1977) Does memory scanning involve implicit speech? In Dornic. S. (Ed.) Attention and Performance, VI. Hillsdale N. J. Erlbaum.

CHI, M. T. H. (1976) Short term memory limitations in children: Capacity or processing defecits? Mem. & Cogn. 4, 559-572.

CIMBALO, R. S., CAPRIA, L., NEIDER, R. A. & WILKINS, M. A. C. (1977) Isolation effect: Overall list facilitation in Short term memory. Acta Psychol. 41, 419-432

CIMBALO, R. S. & PELENERO, K. C. (1970) The isolation effect and mechanisms in short and long-term memory. Psychon. Sci. 21, 69 - 70.

CLIFTON, C & TASH, J. (1973) Effect of syllabic word length on memory search rates. J. Exp. Psychol. 99, 231-235.

COLE, R.A. & YOUNG, M. (1975) Effect of subvocalization on memory for speech sounds. J. Exp. Psychol. Hum. Learn & Mem. 1, 772-779.

COLLE, H. & WELSH, A. (1976) Acoustic masking in primary memory. J. verb. Learn. verb. Behav. 15, 17-31.

COLTHEART, M. (1980) Reading, phonological recoding and deep dyslexia. In Coltheart, M., Patterson, K. & Marshall, J. (Eds.) Deep dyslexia. Routledge, Kegan, Paul. London.

CONRAD, R. (1964) Acoustic confusion and immediate memory. Brit. J. Psychol. 55, 75-84

CONRAD, R. (1967) Interference or decay over short retention intervals. J. verb. Learn. verb. Behav. 6, 49-54

CONRAD, R. (1972) Speech and reading. In Kavanagh. J.F. & Mattingly, I. (Eds.) Language by ear and by eye. Cambridge. M.I.T. Press.

CONRAD, R. & HULL, A.J. (1964) Information, acoustic confusion and memory span. Brit. J. Psychol. 55, 429-432.

CRAIK, F.I. & BLANKESTEIN, K.R. (1975) Psychophysiology and human memory. In Venables, P.H. & Christie, M.J. (Eds.) Research in Psychophysiology. Wiley, Lond.

CRAIK, F.I.M. & LOCKHART, R.S. (1972) Levels of processing: A framework for memory research. J. verb. Learn. verb. Behav. 11, 671-684.

CROWDER, R.G. (1968) Intra-serial repetition effects in immediate memory. J. verb. Learn. verb. Behav. 7, 446-451

CROWDER, R.G. (1978) Audition and speech coding in short-term memory: a tutorial review. In Requin. J. (Ed.) Attention and Performance VII, LEA. Hillsdale. N.J.

DAEE, S & WILDING, J. (1977) Effects of high intensity white noise on short term memory for position in a list and sequence. Brit. J. Psychol. 68, 335-349.

DAVIES, D.R. & JONES, D.M. (1975) The effects of noise and incentive upon attention in short term memory. Brit. J. Psychol. 66, 61-68.

DORNIC, S. (1975) Some studies on the retention of order information. In P.M.A. Rabbitt & S. Dornic (Eds.) Attention and Performance Vol. V. Academic Press. London.

DORNIC, S., HAGDAHL, R. & HANSON, G. (1973) Visual search and short term memory in the deaf. Reports from the Institute of Applied Psychol., The University of Stochholm. No. 38.

DUNN, J.A. (1968) Anxiety, stress and the performance of complex intelluctual tasks: A new look at an old question. J. Consult. Clin. Psychol. 32, 669-673.

EASTERBROOK, J.A. (1959) The effect of emotion on cue utilization and the organisation of behaviour. Psychol. Rev. 66, 183-201.

ERICKSON, C. W., POLLACK, M. D. & MONTAGUE, W. E. (1970) Implicit speech: Mechanisims in perceptual coding. J. Exp. Psychol. 84, 502-507.

ESTES, W. K. (1973) Phhonemic coding and rehearsal in short term memory for letter strings. J. verb. Learn. verb. Behav. 12, 360-372.

EYSENCK, H. J. (1967) The Biological Basis of Personality. Springfield, Illinois. C. C. Thomas Publishers.

EYSENCK, M. W. (1974) Individual differences in speed of retrieval from semantic memory. J. Res. Person. 8, 307-323.

EYSENCK, M. W. (1975) Effects of noise, activation level and response dominance on retrieval from semantic memory. J. Exp. Psychol. Hum. Learn. Mem. 104, 143-148.

EYSENCK, M. W. (1976) Arousal, learning and memory. Psychol. Bull. 83, 389-404.

EYSENCK, M. W. (1977) Human memory: Theory, Research and Individual Differences. Oxford. Pergamon Press.

EYSENCK, M. W. & EYSENCK, M. C. (1979) Memory scanning, Introversion-Extraversion and levels of processing. J. Res. in Person. 13, 305-315.

FOLKARD, S. (1976) The reduction of subvocal activity under stress, and its effects on information processing and memory. Paper presented to: Symposium No. 26: Information Processing and Stress. XXIst International Congress of Psychology. Paris. 1976.

FOLKARD, S. (1979) Time of day and level of processing. Mem. & Cogn. 7, 247-252.

FOLKARD, S. (1980) A note on "Time of day effects in school children's immediate and delayed recall of meaningful material " the influence of the importance of the information tested. Brit. J. Psychol. 71, 95-97.

FOLKARD, S. & MONK, T.H. (1979) Time of day and processing strategy in free recall. Quart. J. Exp. Psychol. 31, 461-475.

FOWLER, C.J.H. & WILDING, J. (1979) Differential effects of noise and incentives on learning. Brit. J. Psychol. 70, 149-153.

GARRITY, L.I. (1977) Electromyography: A review of the current status of the subvocal speech research. Mem. & Cogn. 5, 615-622.

GOOLKASIAN, P. & EDWARDS, D.C. (1977) The effect of loud noise on the psychological refractory period. Bull. of the Psychonom. Soc. 9, 139-141.

GLASSMAN, W.E. (1972) Subvocal activity and acoustic confusions in short term memory. J. Exp. Psychol. 96, 164-169.

GRIFFITHS, J. (1958) The effect of experimentally induced anxiety on certain subtests of the Wechsler-Bellevue. Diss. Abstrs. 18, 655-656.

HALL, J.W., GROSSMAN, L.R. & ELWOOD, K.D. (1976) Differences in encoding for free recall vs recognition. Mem. & Cogn. 4, 507-513.

HALL, J.W.. MISKIEWICZ, R. & MURRAY, C.G. (1977) Effects of test expectancy (recall vs recognition) on children's recall and recognition. Bull. of the Psychonom. Soc. 10, 425-428.

HAMILTON, P., HOCKEY, G.R.J.,& QUINN, J.G. (1972) Information selection, arousal and memory. Brit. J. Psychol. 63, 181-189.

HAMILTON, P., HOCKEY, G.R.J. & REJMAN, M. (1977) The place of the concept of activation in human information theory: An integrative approach. In S. Dornic (Ed.) Attention and Performance. Vol. VI. Hillsdale. N.J. Erlbaum.

HARTLEY, L.R. (1981) Noise does not impair by masking: A reply to Poulton's "Composite model for human performance in continous noise". Psychol. Rev. 88, 86-89.

HAVEMAN, J. & FARLEY, F.H. (1969) Arousal and retention in paired-associate, serial and free learning. Tech. Rep. 91. Madison: Wisconsin Research and Development Centre for Cognitive Learning.

HEALY, A.F. (1975) Coding of temporal-spatial patterns in short term memory. J. verb. Learn. verb. Behav. 14, 481-495.

HEBB, D.O. (1955) Drives and the C.N.S. (Conceptual Nervous System). Psychol. Rev. 62, 243-254.

HINTZMAN, D.L. (1967) Articulatory coding in short term memory. J. verb. Learn. verb. Behav. 6, 312-316.

HOCKEY, G.R.J. (1970) Effects of loud noise on attentional selectivity. Quart. J. Exp. Psychol. 22, 28-36.

HOCKEY, G.R.J. (1977) Arousal and stress in human memory: Some methodological and theoretical considerations. In Gruneberg. M.M., Morris, P.E. & Sykes, R.N. (Eds.) Practical Aspects of Memory. London. Academic Press.

HOCKEY, G.R.J. (1979) Stress and the cognitive components of skilled performance. In V. Hamilton and D.M. Warburton (Eds.) Human Stress and Cognition: An Information Processing Approach. Wiley.

HOCKEY, G.R.J. & HAMILTON, P. (1970) Arousal and information selection in short term memory. Nature, Lond. 226, 866-867.

HODGES, W.F. (1968) Effects of ego threat and pain on state anxiety. J. Person. Soc. Psychol. 8, 364-372.

HORMANN, H. & OSTERKAMP, U. (1966) Uber den Einfluss von kontinuierlichem Larm auf die Organisation von Gedachtnisinhalten. Z. exp. angew. Psychol. 13, 31-38.

JOHANSSON, B.S. (1970) Attention and the von Restorff effect. Brit. J. Psychol. 61, 163-170.

JONES, D., GALE, A. & SMALLBONE, A. (1979) Short term recall of nine digit srtings and the E.E.G. Brit. J. Psychol. 70, 97-119.

KAPLAN, S. & KAPLAN, R. (1968) Arousal and memory: A comment. Psychonom. Sci. 10, 291-292.

KAPLAN, S., KAPLAN, R. & SAMPSON, J.R. (1968) Encoding and arousal factors in free recall of verbal and non-verbal material. Psychonom. Sci. 12, 73-74.

KATZ, R.B., SHANKWEILER, D. & LIBERMAN, I.Y. (1981) Memory for item order and phonetic recoding in the beginning reader. J. Exp. Child Psychol. 32, 474-484.

KLAPP, S.T. (1971) Implicit speech inferred from response latencies in same different decisions. J. Exp. Psychol. 91, 262-267.

KLEIMAN, G.M. (1975) Speech recoding in reading. J. verb. Learn. verb. Behav. 14, 323-340.

KLEINSMITH, L.J. & KAPLAN, S. (1963) Paired-associate learning as a function of arousal and interpolated interval. J. Exp. Psychol. 65, 190-193.

KLEINSMITH, L.J. & KAPLAN, S. (1964) Interaction of arousal and recall interval in nonsense syllable paired-associate learning. J. Exp. Psychol. 67, I24-126.

LACEY, J.I. (1967) Somatic response patterning and stress: Some revisions of activation theory. In M.H. Appley and R. Trumbull (Eds.) Psychological Stress: Issues in Research. Appleton Century Croft. New York.

LADER, M. (1975) The psychophysiology of mental illness. Routledge and Kegan Paul, London.

LEE, C.L. (1976) Short term recall of repeated items and detection of repetitions in letter sequences. J. Exp. Psychol. Hum. Learn. & Mem. 2, 120-127.

LEE, C.L. (1976, b) Repetition and acoustic contrast in short term memory for letter sequences. J. Exp. Psychol. Hum. Learn & Mem. 2, 695-704.

LEVONIAN, E. (1967) Retention of information in relation to arousal during continously presented material. Amer. Educ. Res. Journal. 4, 103-116.

LEVY, B.A. (1975) Vocalization and suppression effects in sentence memory. J. verb. Learn. verb. Behav. 14, 304-316.

LEVY, B.A. (1978) Speech processing during reading. In A.M. Lesgold, J.W. Pellegrino, Fokkema & Glaser (Eds.) Cognitive Psychology and Instruction. N.Y. Plenum.

LEWIS, E.K. (1981) Influences of noise and time of day on memory strategies in recall and recognition. Unpublished Ph. D. Thesis, Univ. of London.

LIBERMAN, I.Y., SHANKWEILER, D., LIBERMAN, A.M., FOWLER, C. & FISCHER, F.W. (1977) Phonetic segmentation and reading in the beginning reader. In A.S. Reber and D. Scarborough (Eds.) Towards a Psychology of Reading: The Proceedings of the CUNY Conference. Hillsdale, N.J. Earlbaum.

LOCKE, J.L. & FEHR, F.S. (1971) Phonetic correlates of graphic recall. Percept. & Motor Skills. 33, 1040-2.

LOFTUS, G. (1971) Comparison of recognition and recall in a continous memory task. J. Exp. Psychol. 91, 220-226.

McCUSKER, L.X., HILLINGER, M.L. & BIAS, R.G. (1981) Phonological recoding and reading. Psychol. Bull. 89, 217-245.

Mc CLEAN, P.D. (1969) Induced arousal and time of recall as determinants of paired-associate recall. Brit. J. Psychol. 60, 57-62.

MACKWORTH, J.F. (1963) The relation between the visual image and post-perceptual immediate memory. J. verb. Learn. verb. Behav. 2, 75-85.

MAISTO, S.A., DEWAARD, R.J. & MILLER, M.E. (1977) Encoding processes for recognition and recall. Bull. of the Psychonom. Soc. 9, 127-130.

MALMO, R.B. (1957) Anxiety and behavioural arousal. Psychol. Rev. 64, 276-287.

MALTZMAN, I., KANTOR, W. & LANGDON, B. (1966) Immediate and delayed retention, arousal, and the orienting and defensive reflexes. Psychonom. Sci. 6, 445-446.

MARTIN, M. (1978) Speech recoding in silent reading. Mem. & Cogn. 6, 108-114.

MEYER, D.E., SCHANEVELDT, R.W. & RUDDY, M.G. (1974) Function of graphemic and phonemic codes in visual word recognition. Mem. & Cogn, 2, 309-321.

MILLAR, K. (1979) Noise and the rehearsal masking hypothesis. Brit. J. Psychol. 70, 565-577.

MILLAR, K. (1979, b) Word recognition in lod noise. Acta Psychol. 43, 225-237.

MILLER, M. G. (1957) Effects of high intensity noise on retention. J. Applied Psychol. 41, 370-372.

MOHINDRA, N. & WILDING, J. (1983) Noise effects on rehearsal rate in short term serial order memory. Quart. J. Exp. Psychol. (in press).

MOLDAWSKY, S. & MOLDAWSKY, P. C. (1952) Digit span as an anxiety indicator. J. Consult. Psychol. 16, 115-118.

MUELLER, J.H. (1976) Anxiety and cue utilization in human learning and memory. In M. Zuckerman and C. D. Spielberger (Eds.) Emotions and Anxiety: New concepts, Methods and Applications. LEA 1976.

MUELLER, J.H. (1977) Test anxiety, input modality and levels of organization in free recall. Bull. Psychonom. Soc. 9, 67-69.

MUELLER, J.H. (1978) The effects of individual differences in test anxiety and type of orienting task on levels of organization in free recall. J. Res. Person. 12, 100-116.

MUELLER, J.H. & OVERCAST, T.D. (1976) Free recall as a function of test anxiety, concreteness and instructions. Bull. Psychonom. Soc. 8, 194-196.

MUELLER, J.H., CARLOMUSTO, M. & MARLER, M. (1977) Recall as a function of method of presentation and individual differences in test anxiety. Bull. Psychonom. Soc. 10, 447-450.

MUELLER, J.H., CARLOMUSTO, M. & MARLER, M. (1978) Recall and organization in memory as a function of method of presentation and individual differences in test anxiety. Bull. Psychonom. Soc. 12, 133-136.

MURRAY, D. E. (1965) The effect of white noise upon the recall of vocalized lists. Canad. J. Psychol. 19, 304-315.

MURRAY, D. J. (1966) Intralist interference and rehearsal in short term memory. Canad. J. Psychol. 20, 413-426.

MURRAY, D. J. (1967) The role of speech responses in short term memory. Canad. J. Psychol. 21, 263-276.

MURRAY, D. J. (1968) Articulation and acoustic confusability in short term memory. J. Exp. Psychol. 78, 679-684.

OBONAI, T. & TATSUNO, C. (1954) Facilitation and inhibition in memorizing a series of digits or letters. Japanese Psychol. Res. 1, 1-8.

PARKER, E.S., ALKANA, R.L., BIRNBAUM, I.M., HARTLEY, J. T. & NOBLE, E.P. (1974) Alcohol and the disruption of cognitive processes. Arch. Gen.Psychiat. 31, 824-828.

PETERSON, L. R & JOHNSON, S. T. (1971) Some effects of minimizing articulation on short term retention. J. verb. Learn. verb. Behav. 10, 346-354.

POSNER, M. I. & KONICK, A. W. (1966) On the role of interference in short term retention. J. Exp. Psychol. 72, 221-231.

POTTS, G. R. & SHIFFRIN, R. M. (1970) Repetitions, blank trials and the von Restorff effect in free recall memory. J. Exp. Psychol. 86, 128-130.

POULTON, E. C. (1976) Continous noise interferes with work by masking auditory feedback and inner speech. Applied Ergonomics, 7, 79-84.

POULTON, E. C. (1977) Continous intense noise masks auditory feedback and inner speech. Psychol. Bull. 84, 977-1001.

POULTON, E. C. (1979) Composite model of human performance in continous noise. Psych. Rev. 86, 361-375.

PYKE, S. & AGNEW, N. (1963) Digit span performance as a function of noxious stimulation. J. Consult. Psychol. 27, 281.

RICHARDSON, J. T. E., GREAVES, D. E. & SMITH, M. M. C. (1981) Does articulatory suppression eliminate the phonemic similarity effect in short term recall ? Bull. of Psychonom. Soc.

ROSEN, L. J. & LEE, C. L. (1976) Acute and chronic effects of alcahol use on organizational processes in memory. J. Abnorm. Psychol. 85, 309-317.

RUBENSTEIN, H., LEWIS, S. S., & RUBENSTEIN, M. A. (1971) Evidence for phonemic recoding in visual word recognition. J. verb. Learn. verb. Behav. 10, 647-57.

SALAME, P. & WITTERSHEIM, G. (1978) Selective noise disturbances of the information input in short term memory. Quart. J. Exp. Psychol. 30, 693-704.

SAMPSON, J. R. (1969) Further study of encoding and arousal factors in free recall of verbal and visual material. Psychonom. Sci. 16, 221-222.

SCHONPFLUG, W. (1966) Paarlernen, Behaltensdauer und Activierung. Psychologische Forschung. 29, 132-148.

SCHONPFLUG, W. & BEIKE, P. (1964) Einpragen and Activierung bei gleichzeitiger Variation der Absictlich keit des Lernens und der Ich-Bezogenheit des lernstoffs. Psychologische Forschung. 27, 366-376.

SCHONPFLUG, W. & SCHAFFER, M. (1962) Retention und Aktivation bei akustischer Zusatzreizung. Z. exp. Psychol. 9, 452-464.

SCHWARTZ, S. (1973) The effects of arousal on recall, recognition and the organization of memory. Paper presented at the annual mmeting of the Psychonomic Society, St. Louis. Missouri. November 1973.

SCHWARTZ, S. (1974) Arousal and recall: Effects of noise on two retrieval strategies. J. Exp. Psychol. 102. 896-898.

SHANKWEILER, D. & LIBERMAN, I. Y. (1976) Exploring the relations between reading and speech. In R. M. Knights and D. J. Bakker (Eds.) Neuropsychology of Learning Disorders. University Park Press. Baltimore.

SHANKWEILER, D., LIBERMAN, I.Y., MARK, L.S., FOWLER, C. & FISCHER, F.W. (1979) The speech code and learning to read. J. Exp. Psychol. Hum. Learn. & Mem. 5, 531-545.

SLOBODA, W. & SMITH, E.E. (1968) Disruption effects in human short term memory: Some negative findings. Percept. and Motor Skills. 27, 575-582.

SMITH, A. (1980) Low levels of noise and performance. In J. Tobias (Ed.) Proceedings of the Third International Congress on Noise as a Public Health Problem. ASHA.

SMITH, A., JONES, D. & BROADBENT, D.E. (1981) The effects of noise on recall of categorized lists. Brit. J. Psychol. 72, 299-316.

SPERLING, G. (1960) The information available in a brief visual presentation. Psychol. Monogr. , 74 (Whole No. 498).

STERNBERG, S. (1966) High speed scanning in human memory. Science. N.Y. 153, 652-654.

STOCK, W.A. (1970) Structure and short term memory. Psychonom. Sci. 18, 213-214.

TELL, P.M. (1972) The role of certain acoustic and semantic factors at short and long retention intervals. J. verb. Learn. verb. Behav. 11, 455-464.

THAYER, R.E. (1967) Measurement of activation through self report. Psychol. Rep. 20, 663-678.

TULVING. E (1972) Episodic and semantic memory. In E. Tulving and W. Donaldson (Eds.) Organization and Memory. Academic Press. London.

UNDERWOOD, G. (1978) Attentional selectivity and behavioural control. In G. Underwood (Ed.) Strategies of Information processing . Academic Press. London.

VON RESTORFF (19 3) Uber die Wirkung von Bereichs bildingen in Spurenfeld. Pschol. Forsch. 18, 299-342.

WALKER, E. L. & TARTE, R. D. (1963) Memory storage as a function of arousal and time with homegenous and hetrogenous lists. J. verb. Learn verb. Behav. 2, 113-119.

WALKER, E. L. (1958) Action decrement and its relation to learning. Psychol. Rev. 65, 129-142.

WALLACE, W. P. (1965) Review of the historical, empirical and theoretical status of the von Restorff phenomenon. Psychol. Bull. 63, 410-424.

WALSH, D. A. & JENKINS, J. J. (1973) Effects of orienting tasks on free recall in incidental learning: "Difficulty", "Effort", "Process" Explanations. J. verb. Learn. verb. Behav. 12, 481-488.

WAUGH, N. C. & NORMAN, D. A. (1965) Primary memory. Psychol. Rev. 72, 89-104.

WEINGARTNER, H. & FAILLACE, L. A. (1971) Alcahol state dependent learning in man. J. Nerv. Ment. Dis. 153, 395-406.

WICKELGREN, W. A. (1965) Acoustic similarity and intrusion errors in short term memory. J. Exp. Psychol. 70, 102-108.

WICKELGREN, W.A. (1965, b) Short term memory for repeated items. Quart. J. Exp. Psychol. 17, 14-25.

WICKELGREN, W.A. (1969) Auditory and articulatory coding in verbal short term memory. Psych.Rev. 232-235.

WILDING, J. (1980) Passive and strategic changes in arousal. Paper presented at the'arousal and memory' workshop. Bedford College. December 1980.

WILDING, J. & MOHINDRA, N. (1980) Effects of subvocal suppression, articulating aloud and noise on sequence recall. Brit. J. Psychol. 71, 247-261.

WILDING, J. & MOHINDRA, N. (1981) Ratings of the degree of synonymity of 279 noun pairs. Brit. J. Psychol. 72, 231-240.

WILDING, J., MOHINDRA, N. & BREEN- LEWIS, E.K. (1982) Noise effects in free recall with different orienting tasks. Brit. J. Psychol. 73, 479-486.

WILDING, J. & MOHINDRA, N. (1982) Noise impairs phonological but not semantic access. Paper presented to the Brtitish Psychological Society London Conference, University College London. December 1982.

WILKINSON, R. T. (1975) Noise, incentive and prolonged work: Effects on short term memory. Paper presented at the American Psychological Assoc. Chicago.

YERKES, R.M. & DODSON, J.D. (1908) The relation of strength of stimulus to rapidity of habit formation. J. Comp. Neuro. Psychol. 18, 459-482.

TABLES OF RAW DATA

```
                               ***   EXPERIMENT 1   ***
REPETITION                  REPET                                 NOREPET
LAG                  0                 2                 0                 2
CONTEXT          NON-CON    CON    NON-CON    CON    NON-CON    CON    NON-CON    CON
SERIAL POST.     1234567 1234567 1234567 1234567 1234567 1234567 1234567 1234567
NOISE LEVEL: 65dBC
 S1     DISIM    2222123 3333323 3112113 3131122 3221113 3223202 3113222 3121231
        SIM      2112121 3133213 3100021 3211122 3220110 3133123 3211000 3322223

 S2     DISIM    3333232 3333223 3323233 3332123 3323233 3323112 3333323 3321123
        SIM      2333333 3333333 2312002 3333333 3223223 3312233 2222111 3322323

 S3     DISIM    3333213 3333222 3333223 2232001 3333333 3233301 3223323 3331010
        SIM      3322211 3333333 3221212 3333223 2110102 3333323 3100213 3322123

 S4     DISIM    1133101 2322001 3111011 2210000 3201001 2311010 3212002 2201011
        SIM      1211000 2222102 3312101 3222220 1010112 3220002 2221000 3110221

 S5     DISIM    3133213 3233113 2000013 3130133 3211123 3101003 2233222 3323002
        SIM      2111032 2222223 2321101 2112122 3210111 3211113 2210011 2111113

 S6     DISIM    2232012 3333102 3233223 3330021 3333213 3232201 3333223 3232100
        SIM      2332211 3333122 2221101 2333102 1100110 3311013 2220001 3223203

 S7     DISIM    3333323 3333123 3333313 3221102 3333333 3223222 3333333 3231032
        SIM      2222211 3222223 3322011 3322113 3301111 3311222 3221101 3321202

 S8     DISIM    3333113 2333113 3223213 2131130 3331233 2222231 3332223 3332222
        SIM      2022111 3333333 3101032 2213232 3101201 3312122 3232012 3221122

 S9     DISIM    2231100 2122001 2221123 1021101 2223102 2101011 3320202 2211210
        SIM      2000100 3333103 0001212 1320012 2210001 2101122 1010101 2211221

 S10    DISIM    3223113 3223112 3222203 2200012 2233113 1113010 3333323 1222010
        SIM      2100122 3112223 3111111 2111112 2312011 3211112 1200011 3100112
 NOISE LEVEL: 85 dBC
 S11    DISIM    3222213 3322111 3121102 3311112 3301000 3312112 3212122 3222010
        SIM      3311211 3323323 3320112 3221102 3310000 3200301 3320101 3121200

 S12    DISIM    3200002 3233101 2222123 3210012 3332223 3121102 2322213 2102000
        SIM      3111113 2332123 2121002 3000113 2100001 3111013 3110122 3101203

 S13    DISIM    2111202 3233223 2333222 3331213 3332021 3333101 3323003 3221200
        SIM      2233110 3333233 3321121 3232111 2233323 2233112 3121101 3221323

 S14    DISIM    3223112 3322221 2222013 1121232 2221222 3333001 2223012 2212112
        SIM      1121212 2232013 3211113 3212011 3311102 3200112 3221002 3221210

 S15    DISIM    3323133 3333322 3232313 3100112 3232222 3333112 3323223 3210010
        SIM      3233001 3322213 3211011 3201103 3232101 3310123 3311211 3222323

 S16    DISIM    3222101 3333121 3222311 3200211 3320001 3311021 3332221 3310013
        SIM      3313100 3313011 3332101 2121001 3211133 3212111 3331000 2122012

 S17    DISIM    3211122 3222002 3122213 3332021 3222002 3332000 3333112 3221012
        SIM      3223111 3333313 3111013 3232121 3110002 3310002 3221000 3010001

 S18    DISIM    3333211 3333102 3122001 2231000 3221003 3213001 2132123 1231001
        SIM      1111200 3333113 3332010 3322101 2200111 2100112 3312002 3221001

 S19    DISIM    3222102 3212001 3212223 2132130 3122103 1232000 3222002 2111100
        SIM      2222000 2311023 2122000 2001102 2000010 3321023 2102110 3300003

 S20    DISIM    2233112 3233222 3333231 2121132 3333223 3233210 2232012 3233110
        SIM      3333212 2233212 3233132 3333231 3333211 3322112 3313102 2231222
```

```
                                 ***   EXPERIMENT 2  ***
REPETITION                 REPET                          NOREPET
LAG                  0               2               0               2
CONTEXT        NON-CON   CON   NON-CON   CON   NON-CON   CON   NON-CON   CON
SERIAL POST.   1234567 1234567 1234567 1234567 1234567 1234567 1234567 1234567

  NOISE LEVEL: 65dBC

  S1   DISIM   3322223 3333001 3333223 3333231 3223113 3233112 3223233 3333332
       SIM     3322222 3333213 3333222 2323323 3320020 3333333 3221110 3232223

  S2   DISIM   3333333 3333333 3333333 3322233 3333333 3333222 3333333 3332232
       SIM     3333332 3333333 3322123 3333333 3332123 3311233 3211233 3333333

  S3   DISIM   3211223 3233232 3222110 3330012 3321011 3322100 3323122 3122112
       SIM     3222112 2222213 3322101 3120030 3331001 3112112 3322120 3111101

  S4   DISIM   3333333 2322222 3323233 3331232 3333323 3333313 3222233 3331111
       SIM     3322210 3333323 3321112 3333323 3310012 3321223 3202133 3332113

  S5   DISIM   3333333 3333322 3333222 3333122 3333322 3222222 3333332 2332220
       SIM     3221122 3333322 3322022 3332213 3322102 3321013 3323222 3331122

  S6   DISIM   3333333 3333323 3333233 3331122 3333333 3333202 3333333 2332122
       SIM     2211011 3333333 3331121 3333333 3333222 3233223 3332122 3333333

  S7   DISIM   3333101 3333121 3311233 3321010 3333213 3301000 3322122 3331011
       SIM     3322133 3333312 3311000 3210021 3322202 3233211 3321001 3321323

  S8   DISIM   3322102 3333111 3212013 1121021 3321111 3221010 3333122 1133111
       SIM     3111001 3322103 3233001 3332122 1100000 3111101 3203100 3222100

  S9   DISIM   3333333 3333332 3333333 3322122 3323223 3333102 3333333 3332121
       SIM     3333232 3333333 3323323 3333323 3322102 3333333 3333212 3333333

  S10  DISIM   3333333 3333322 3333103 2320012 3321123 3333200 3333223 3330101
       SIM     3333333 3333223 3330021 3333102 3331000 3322222 3322211 3323303

  NOISE LEVEL: 85dBC

  S11  DISIM   3333333 3333333 3333333 3333222 3333333 3333333 3333333 3232332
       SIM     3333333 3333333 3222223 3323333 3332113 3333333 3322123 3333333

  S12  DISIM   3222223 3322112 3333333 3332101 3333223 2212121 3322233 3321011
       SIM     3222211 3333223 3332212 3332232 3222112 3311322 3333222 3333332

  S13  DISIM   3222110 3223211 3232120 3231101 3320100 3221010 3222221 2111100
       SIM     3111100 3323112 3331111 3313311 3332010 3200001 3321000 3201200

  S14  DISIM   3322322 3333111 3111022 3220110 3111002 3220010 3312112 3331001
       SIM     3211112 3333213 3331012 3331002 3331020 3310001 3321100 3320002

  S15  DISIM   3333333 3333333 3333333 3332232 3333333 3333212 3333313 3333232
       SIM     3333333 3333333 3222223 3333333 2112311 3211213 3222012 3223323

  S16  DISIM   3333332 3333333 3322311 3331222 3332112 3322222 3332233 3331231
       SIM     3323133 3333333 3322212 3333222 3322102 3311112 3322011 3332122

  S17  DISIM   3333333 3333323 3333333 3321123 3333333 3333232 3333333 3333122
       SIM     3333232 3333333 3333022 3332233 3333001 3322333 3323212 3333333

  S18  DISIM   2322332 3333333 2232122 3331120 3333123 3333232 3333112 3231211
       SIM     3211022 3222333 2211121 3232112 3332223 2323233 3322012 3332223

  S19  DISIM   3333323 3233010 3210003 3120011 3121013 3100011 3321002 2101000
       SIM     3221221 3333113 3211100 3111001 3111000 3332213 3211100 3322102

  S20  DISIM   2211011 3222121 3330011 3110011 3210012 3322100 3231003 3332100
       SIM     3210001 3322011 3130000 2211013 3332121 3231111 3221010 3201012
```

```
                         ***  EXPERIMENT 3  ***

     RATE                      FAST                    SLOW
     DELAY               SHORT      LONG         SHORT        LONG
     CONFUSABILITY  C      NC    C      NC    C      NC    C      NC
     SERIAL POST.   12345 12345 12345 12345 12345 12345 12345 12345

     NOISE LEVEL: 65dBC

S1   NO-ARTIC       11111 33110 32010 32123 22223 33333 33232 33333
        ARTIC       33020 31111 32100 33110 33333 33333 33333 33333

S2   NO-ARTIC       33200 32322 33223 33222 33332 32223 32132 32212
        ARTIC       32323 32211 33333 22223 32112 32123 33113 31102

S3   NO-ARTIC       31211 33333 20012 33222 31313 33322 33311 33333
        ARTIC       33001 33333 21223 33333 22123 33333 33223 32223

S4   NO-ARTIC       20010 32311 00101 31211 11000 21111 20012 33333
        ARTIC       01101 33322 22112 32222 11112 33223 00100 33223

S5   NO-ARTIC       31011 20011 31011 11122 33322 32122 33333 32233
        ARTIC       31012 21211 22211 33212 32233 22222 33333 33333

S6   NO-ARTIC       32021 33101 31112 32122 31121 33333 32211 33333
        ARTIC       31222 22123 30022 33113 33333 33333 31022 33333

S7   NO-ARTIC       32211 22212 31221 33011 30101 32323 21001 33333
        ARTIC       30100 32100 31101 33102 31212 33223 22112 32123

S8   NO-ARTIC       32222 33322 32202 33223 31111 32232 32123 33223
        ARTIC       33113 33322 32221 33333 21100 33322 33222 33333

S9   NO-ARTIC       32101 21101 21103 33322 33333 33333 33333 22333
        ARTIC       22112 32112 33322 31011 33333 33333 32222 33333

S10  NO-ARTIC       32212 22223 31102 33232 32200 33333 22123 33333
        ARTIC       31122 33333 23112 31213 32222 33333 32123 33333

NOISE LEVEL: 85dBC

S11  NO-ARTIC       33201 31110 31111 32222 33322 33333 32232 33333
        ARTIC       32111 32221 33211 33333 32122 33333 22133 33333

S12  NO-ARTIC       33212 22222 33333 32223 33113 33333 33322 32223
        ARTIC       33232 32121 33232 33333 31122 33333 33333 33333

S13  NO-ARTIC       31211 31123 20023 33333 32222 33333 30013 32233
        ARTIC       31011 32223 30213 21123 32202 33333 32113 33333

S14  NO-ARTIC       20113 33333 30111 32223 33311 33333 33211 33333
        ARTIC       10021 33222 22100 33322 33322 33333 32132 33322

S15  NO-ARTIC       31101 33102 21222 32322 32112 33333 33121 33333
        ARTIC       33211 21201 33223 33322 31012 33223 22112 33333

S16  NO-ARTIC       31211 21211 31210 33333 31112 33333 32222 33333
        ARTIC       22021 33222 21111 33211 32112 33333 22002 33333

S17  NO-ARTIC       33222 32022 32112 33223 32312 33112 33333 33333
        ARTIC       21123 10002 13021 21102 32121 23212 21100 33333

S18  NO-ARTIC       21301 32233 30000 32233 32112 22233 32222 33333
        ARTIC       33011 32212 33222 33223 33333 33333 32332 33333

S19  NO-ARTIC       33333 33333 22212 22121 32122 33333 32233 33333
        ARTIC       33333 33223 32223 11223 33223 33333 22333 33333

S20  NO-ARTIC       21123 32112 30102 10312 32111 33223 33322 32233
        ARTIC       32312 33113 33223 32112 33223 33322 30011 22233
```

```
                     ***  EXPERIMENT 4  ***

RATE                   FAST                    SLOW
DELAY              SHORT      LONG        SHORT       LONG
CONFUSABILITY    C     NC    C     NC    C     NC    C     NC
SERIAL POST.   12345 12345 12345 12345 12345 12345 12345 12345

NOISE LEVEL: 65dBC

S1   NO-ARTIC  31021 21001 22100 21111 32121 33333 22212 32223
        ARTIC  22111 22221 31022 32100 32121 32223 22001 33333

S2   NO-ARTIC  11211 20002 32110 10112 31223 33212 31121 33333
        ARTIC  32001 33333 32222 21001 21122 33333 31122 32222

S3   NO-ARTIC  11101 31111 30111 33232 10001 33333 21001 33322
        ARTIC  21122 32113 32010 32223 32120 33333 22112 22122

S4   NO-ARTIC  21122 22322 22212 32322 33322 12100 22020 31313
        ARTIC  32222 33223 31112 33333 21102 21323 11101 32323

S5   NO-ARTIC  20101 32211 21100 22222 32011 32222 22122 10111
        ARTIC  11111 21010 31212 11100 11111 22111 30103 33222

S6   NO-ARTIC  21011 32233 22133 21123 21010 32323 31111 21223
        ARTIC  31020 33333 31223 33322 31101 33233 32100 32323

S7   NO-ARTIC  10123 32102 10121 22223 33232 33322 32222 33333
        ARTIC  32201 32101 31211 32211 31133 33333 21200 33333

S8   NO-ARTIC  32111 22121 00011 20102 10001 32323 10221 22112
        ARTIC  20120 21111 22211 21200 21011 33333 31200 22223

S9   NO-ARTIC  32101 32233 32210 32123 11333 32233 22011 22323
        ARTIC  22212 33322 10113 33211 32100 33333 32212 33333

S10 NO-ARTIC   21322 33333 31100 33212 21212 33311 23232 33223
        ARTIC  32111 32233 31002 32113 22112 22333 33322 32233

NOISE LEVEL: 85dBC

S11 NO-ARTIC   31112 33333 22200 33222 32020 33333 32223 33333
        ARTIC  31122 11122 31210 33322 32213 22222 33223 23333


S12 NO-ARTIC   22211 22100 22112 31112 11021 33333 21100 23223
        ARTIC  23111 33011 32122 33311 33003 33333 10001 33333

S13 NO-ARTIC   32132 33322 33311 33333 33223 33333 32212 32323
        ARTIC  33100 33300 33311 33212 33333 33333 33333 33333

S14 NO-ARTIC   31212 00100 20022 10101 21101 32223 21123 21112
        ARTIC  31210 33232 30302 32213 22211 21222 21100 32213

S15 NO-ARTIC   32111 22222 32123 33333 33223 33333 22221 33333
        ARTIC  31212 33333 33333 33333 32222 32233 32222 33333

S16 NO-ARTIC   33333 33322 20012 33223 31222 33333 33322 22222
        ARTIC  21101 33200 20123 33333 32123 33333 33333 33333

S17 NO-ARTIC   10122 22221 30012 11122 32122 32233 32122 33333
        ARTIC  20012 10111 22133 31111 22111 22222 32123 32233

S18 NO-ARTIC   21012 30013 33221 22132 21112 33333 10111 32233
        ARTIC  33100 33333 11011 32001 21112 33333 12232 33333

S19 NO-ARTIC   11030 32223 21001 21122 22200 33333 22111 33333
        ARTIC  32112 31122 31133 32223 32123 33333 32222 33333

S20 NO-ARTIC   00000 11112 11102 20110 21002 12310 10001 21112
        ARTIC  21100 30001 21002 20112 22222 21212 22122 33333
```

*** EXPERIMENT 5 ***

MOISE LEVEL: 65 dBC

	A	B	C	D	E	D'	BETA
S1	14	1	4	2	0	1.75	2.86
S2	11	2	1	0	0	1.83	5.87
S3	22	0	0	0	0	4.58	15.95
S4	21	2	0	1	1	3.11	1.84
S5	16	1	4	3	1	1.85	2.12
S6	19	3	9	7	5	1.64	0.82
S7	22	4	3	0	1	3.11	0.63
S8	12	0	1	1	3	1.80	4.54
S9	15	2	2	4	1	1.73	2.28
S10	23	4	5	3	1	3.7	0.07
S11	17	1	1	0	0	2.69	6.79
S12	23	1	0	2	0	4.46	0.21
S13	14	0	6	1	1	1.68	2.59
S14	12	3	4	0	2	1.39	2.41
S15	17	1	1	0	1	2.52	4.82
S16	13	0	2	1	0	2.04	5.76
S17	10	2	0	1	0	1.71	5.76

NOISE LEVEL: 85dBC

S1	18	2	7	1	1	2.01	1.56
S2	11	1	1	1	0	1.83	5.87
S3	20	6	6	4	4	1.96	0.76
S4	20	0	0	1	0	3.45	8.01
S5	17	1	4	3	0	2.05	2.21
S6	21	2	2	1	0	3.0	1.54
S7	17	0	1	0	0	2.97	12.35
S8	17	1	0	1	0	2.69	6.78
S9	23	0	1	0	1	4.63	0.30
S10	17	2	3	1	2	2.05	2.21
S11	10	1	0	1	0	1.89	8.11
S12	18	0	0	0	0	3.66	50.43
S13	21	1	0	0	0	3.69	5.98
S14	16	3	5	2	0	1.79	1.97
S15	22	1	1	0	0	3.76	1.93
S16	22	0	0	0	0	4.58	15.95
S17	20	9	10	8	9	1.48	0.56

**** EXPERIMENT 6 ***

	RECALL			RECOGNITION			D'	BETA
		A	B	C	D	E		
NOISE LEVEL: 65dBC								
S1	19	22	1	1	1	0	3.09	3.12
S2	16	21	5	7	0	0	2.26	1.35
S3	13	19	0	0	0	0	3.07	12.91
S4	9	17	8	9	7	7	1.23	1.21
S5	12	20	2	2	0	1	2.54	2.97
S6	10	15	3	4	2	2	1.59	2.41
S7	8	15	1	0	1	0	2.37	9.31
S8	11	17	0	1	1	0	2.56	8.07
S9	14	19	0	0	1	0	3.07	12.91
S10	18	20	0	3	0	0	2.77	4.52
S11	11	14	0	0	0	0	2.56	17.98
S12	16	21	0	0	0	0	3.36	10.07
S13	12	19	1	3	0	1	2.40	3.30
S14	4	8	4	6	7	4	0.56	1.53
S15	17	17	1	3	0	1	2.17	3.84
S16	11	20	5	6	5	6	1.78	1.10
S17	16	23	0	0	0	1	3.77	6.16
S18	13	21	4	5	6	2	2.07	1.09
S19	6	6	0	0	1	0	1.70	14.33
NOISE LEVEL: 75dBC								
S1	7	6	3	2	0	2	0.89	2.80
S2	9	14	4	4	6	3	1.27	1.84
S3	8	13	2	1	1	1	1.78	4.37
S4	15	21	1	2	1	2	2.60	2.22
S5	11	16	0	0	0	0	2.72	15.58
S6	16	20	3	1	2	1	2.38	2.30
S7	7	11	3	9	4	1	0.98	1.86
S8	15	19	1	5	1	0	2.25	2.59
S9	14	13	2	1	0	0	1.99	6.51
S10	17	23	1	2	0	0	3.31	2.32
S11	11	19	7	9	4	7	1.53	1.10
S12	8	17	1	4	5	5	1.63	1.79
S13	11	15	0	0	1	0	2.62	16.20
S14	14	17	1	0	1	0	2.56	8.07
S15	14	23	0	1	0	1	3.48	3.22
S16	18	19	1	0	0	0	3.07	12.91
S17	11	15	1	0	0	1	2.37	9.31
NOISE LEVEL: 85dBC								
S1	18	19	1	1	0	1	2.63	5.01
S2	22	22	0	0	0	0	3.54	8.26
S3	18	23	0	0	1	0	3.77	6.16
S4	11	17	2	5	3	1	1.80	2.16
S5	12	16	3	1	0	0	2.17	4.89
S6	11	15	0	0	0	0	2.62	16.20
S7	14	15	1	2	3	2	1.75	3.02
S8	10	20	7	7	5	5	1.73	1.06
S9	12	16	3	1	1	4	1.79	2.64
S10	13	19	4	2	2	0	2.12	2.33
S11	12	17	0	3	2	0	2.17	2.83
S12	14	20	1	0	1	0	2.94	6.37
S13	13	19	0	0	0	0	3.07	12.91
S14	11	20	1	4	4	3	2.11	1.59
S15	10	17	0	3	3	1	2.02	2.99
S16	5	15	3	7	11	5	1.13	1.45

KEY:
A - NO. OF WORDS RECOGNISED
B - SYNONYM CONFUSIONS
C - HIGH ASSOCIATE CONFUSIONS
D - ACOUSTIC CONFUSIONS
E - RANDOM DISTRACTOR CONFUSIONS

*** EXPERIMENT 7 ***

			NON-CONFUSABLE					CONFUSABLE				
	65dBC	READ	270	262	283	254	275	283	374	283	283	316
		REHEARSE	247	248	284	281	270	280	282	278	287	279
S1	85dBC	READ	301	269	288	297	300	326	304	330	294	314
		REHEARSE	300	284	279	281	279	295	309	352	316	291
	65dBC	READ	284	299	280	***	299	334	461	***	362	355
		REHEARSE	296	264	285	267	269	303	309	342	289	492
S2	85dBC	READ	386	359	382	315	315	308	310	580	506	335
		REHEARSE	342	355	259	291	292	477	400	295	341	482
	65dBC	READ	398	411	397	382	422	391	410	***	374	462
		REHEARSE	335	459	378	414	374	419	375	403	423	430
S3	85dBC	READ	415	394	417	419	428	393	372	346	372	419
		REHEARSE	428	386	413	429	417	432	442	423	388	506
	65dBC	READ	468	505	488	467	461	488	479	511	530	482
		REHEARSE	440	436	472	442	496	456	442	545	***	466
S3	85dBC	READ	465	392	425	430	439	473	446	451	446	422
		REHEARSE	467	510	495	513	508	507	471	498	522	548
	65dBC	READ	320	265	283	291	267	302	390	421	391	309
		REHEARSE	266	289	***	251	315	356	322	304	315	441
S4	85dBC	READ	271	280	302	305	265	303	302	312	287	460
		REHEARSE	293	267	419	305	323	371	390	378	398	325
	65dBC	READ	402	398	362	378	384	463	406	407	400	396
		REHEARSE	360	337	418	345	356	398	423	392	379	427
S5	85dBC	READ	306	341	351	341	345	348	345	358	373	320
		REHEARSE	313	344	351	337	315	412	349	349	366	355
	65dBC	READ	402	484	428	502	446	534	530	485	465	491
		REHEARSE	458	437	433	432	423	500	462	436	436	463
S6	85dBC	READ	486	474	498	496	515	514	491	501	550	500
		REHEARSE	554	536	528	537	547	606	557	553	558	562
	65dBC	READ	466	383	421	512	412	464	433	452	428	460
		REHEARSE	517	596	549	411	523	568	600	465	515	476
S7	85dBC	READ	464	425	420	487	468	532	499	512	434	447
		REHEARSE	470	464	413	424	402	463	450	524	422	433
	85dBC	READ	390	409	389	394	377	369	365	407	452	369
		REHEARSE	360	366	378	377	391	340	322	327	349	372
S8	85dBC	READ	346	362	347	378	354	328	320	329	317	369
		REHEARSE	385	369	353	374	393	359	377	363	354	340
	65dBC	READ	387	266	283	280	245	304	366	310	324	388
		REHEARSE	262	248	***	288	246	280	334	***	284	273
S9	85dBC	READ	326	360	300	323	304	***	323	425	340	320
		REHEARSE	296	282	301	285	275	283	312	331	332	316
	65dBC	READ	338	282	315	295	330	309	315	307	285	284
		REHEARSE	295	298	259	277	266	288	292	310	300	292
S10	85dBC	READ	354	347	318	326	303	375	339	326	316	310
		REHEARSE	***	523	492	457	447	494	492	506	489	466

N.B. All scores are in jiffies, 1/60s units.

**** EXPERIMENT 8 *** SINGLE WORD DATA

	65dBC								85dBC							
	1 SYLLABLE				2 SYLLABLES				1 SYLLABLE				2 SYLLABLES			
	SHORT		LONG		SHORT		LONG		SHORT		LONG		SHORT		LONG	
	C	NC	C	NC	C	NC	C	NC	C	NC	C	NC	C	NC	C	NC
S1	144	137	144	149	141	151	149	163	139	137	163	157	148	154	154	156
S2	118	117	127	122	119	119	132	144	116	119	123	121	131	124	140	127
S3	123	125	146	148	149	147	162	165	123	113	144	144	158	141	168	154
S4	129	135	142	141	143	131	143	162	151	143	137	149	152	155	151	169
S5	117	111	122	117	114	131	128	133	121	112	122	124	122	116	131	136
S6	090	087	098	105	108	112	122	131	086	082	094	107	103	109	119	127
S7	122	118	121	132	144	142	139	152	111	112	118	125	129	128	140	143
S8	099	092	099	106	114	103	120	119	107	104	115	115	117	120	139	144
S9	128	115	129	134	133	123	130	131	114	110	120	116	114	114	128	126
S10	120	113	119	120	120	124	133	146	113	115	112	114	114	119	118	126

N.B. All scores are in jiffies, 1/60 s units.

*** EXPERIMENT 8 ***

	65dBC								85dBC							
	1SYLLABLE				2SYLLABLES				1SYLLABLE				2SYLLABLES			
	SHORT		LONG		SHORT		LONG		SHORT		LONG		SHORT		LONG	
	C	NC	C	NC	C	NC	C	NC	C	NC	C	NC	C	NC	C	NC
TASK: READ																
S1	339	264	323	342	302	289	336	375	333	299	306	310	334	291	379	371
S2	257	272	312	268	327	295	390	366	281	207	297	282	312	384	352	375
S3	277	249	318	389	297	279	313	360	375	340	333	294	332	301	384	384
S3	338	244	427	352	364	341	492	438	299	242	329	307	368	318	406	415
S5	277	201	312	238	316	271	338	430	234	207	273	245	328	290	366	381
S6	357	202	308	266	284	278	297	329	346	227	328	279	299	295	329	397
S7	334	244	375	320	329	314	379	390	358	374	336	285	341	303	419	424
S8	255	255	277	240	290	255	306	325	333	284	329	295	329	317	373	360
S9	356	234	425	251	271	288	598	340	330	207	213	223	293	252	576	334
S10	292	295	317	286	301	294	362	346	267	251	262	288	290	284	302	345
TASK:REHEARSE																
S1	327	231	314	284	342	267	408	357	395	251	377	315	390	302	491	413
S2	338	235	354	264	352	300	421	365	314	225	301	272	341	295	463	379
S3	318	239	318	287	329	287	330	338	304	233	368	316	339	296	343	350
S4	481	262	440	326	398	389	614	492	509	274	634	355	500	451	700	532
S5	293	192	311	262	309	255	491	339	351	236	385	270	392	299	501	408
S6	531	209	546	285	326	263	427	341	402	211	648	286	346	282	444	359
S7	391	227	362	280	292	312	512	370	468	223	452	295	303	294	550	388
S8	354	236	363	274	307	273	429	364	396	311	341	335	361	355	471	435
S9	419	227	464	239	358	263	783	351	560	240	514	231	323	267	733	329
S10	291	259	287	277	296	284	346	365	304	270	292	294	291	296	426	362

N.B. Scores shown are in jiffies, 1/60 s units.

*** EXPERIMENT 9 ***

	65dBC			85dBC	
	SHORT	LONG		SHORT	LONG
S1	55321	55432	S21	55532	55533
S2	54110	54122	S22	54210	55101
S3	54345	55414	S23	54201	43323
S4	54455	55543	S24	55431	54321
S5	55554	55543	S25	55534	55533
S6	55433	44433	S26	54511	55101
S7	33444	55445	S27	45413	42201
S8	55421	54311	S28	55554	53111
S9	55544	55544	S29	45541	34443
S10	55532	55532	S30	55544	55454
S11	55444	54524	S31	54334	54444
S12	43120	54300	S32	54542	32445
S13	55232	44444	S33	55522	54431
S14	55322	54232	S34	34112	22013
S15	43323	34221	S35	45223	54323
S16	55434	54442	S36	45443	55553
S17	55544	54554	S37	55321	42112
S18	44434	55312	S38	33433	23123
S19	54423	55421	S39	44303	53322
S20	43531	53302	S40	55510	53311

N.B. Scores represent the number of items recalled at each of the five serial positions.

EXPERIMENT 10

	SYNONYM		RHYME	
	YES	NO	YES	NO
S1	047.25	048.23	058.66	060.10
S2	051.37	066.13	068.94	073.75
S3	057.60	066.07	065.68	069.35
S4	055.41	059.77	055.86	061.97
S5	047.18	049.60	056.78	071.90
S6	043.96	047.66	044.43	050.83
S7	051.28	057.93	071.81	075.48
S8	043.17	058.62	052.81	064.75
S9	052.61	062.14	058.53	067.21
S10	049.38	056.10	059.92	063.15
S11	058.35	067.44	062.57	063.81
S12	052.38	061.79	070.58	072.69
S13	054.69	069.27	061.76	062.50
S14	044.96	054.96	063.70	066.49
S15	044.56	057.69	062.84	057.69
S16	058.07	066.20	071.95	071.25
S17	053.35	067.48	067.59	070.29
S18	053.60	060.70	061.12	072.40
S19	058.82	064.21	070.92	079.17
S20	062.55	068.36	088.33	083.59
S21	050.70	064.39	068.91	072.06
S22	057.62	064.27	074.33	088.22
S23	051.59	058.20	059.03	062.77
S24	044.47	046.78	059.04	061.25
S25	077.37	096.08	102.57	108.37
S26	071.79	086.25	097.48	098.93
S27	066.11	075.80	074.85	081.69
S28	053.59	064.29	066.24	073.04
S29	058.57	061.63	061.08	072.65
S30	062.25	070.60	077.83	087.71
S31	057.92	066.30	077.84	076.90
S32	061.03	067.65	077.61	082.52
S33	047.55	054.40	056.15	057.49
S34	049.28	055.11	063.88	076.23
S35	053.40	059.93	056.50	061.25
S36	054.92	067.96	068.72	085.05

N.B. Scores represent decision times in jiffies 1/60 s units.