AN EXPERIMENTAL STUDY OF THE EFFECTS OF NOISE UPON SHORT TERM MEMORY

A Thesis submitted for the degree of

Doctor of Philosophy

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September 1977

SUMMARY

The overall aim of this study was to examine experimentally the effects of noise upon short-term memory tasks in the hope of shedding further light upon the apparently inconsistent results of previous research in the area. Seven experiments are presented.

The first chapter of the thesis comprised a comprehensive review of the literature on noise and human performance while in the second chapter some theoretical questions concerning the effects of noise were considered in more detail followed by a more detailed examination of the effects of noise upon memory.

Chapter 3 described an experiment which examined the effects of noise on attention allocation in short-term memory as a function of list length. The results provided only weak evidence of increased selectivity in noise. In further chapters noiseeffects were investigated in conjunction with various parameters of short-term memory tasks e.g. the retention interval, presentation rate. The results suggested that noise effects were significantly affected by the length of the retention interval but not by the rate of presentation.

Later chapters examined the possibility of differential noise effects on the mode of recall (recall v. recognition) and the type of presentation (sequential v. simultaneous) as well as an investigation of the effect of varying the point of introduction of the noise and the importance of individual differences in noise research.

The results of this study were consistent with the hypothesis that noise at presentation facilitates phonemic coding. However, noise during recall appeared to affect the retrieval strategy adopted by the subject.

ACKNOWLEDGEMENTS

I would like to express my gratitude to everybody who has helped and encouraged me during the long gestation period of this thesis.
Dr Roy Davies, my supervisor, was always ready to offer assistance and advice. Mrs Christine Maddison also deserves my thanks for both deciphering my handwriting and for producing accurate typescripts at remarkable speed.

Acknowledgements are due to Professor W T Singleton for providing Departmental facilities, and to the technical staff, who assembled the experimental equipment. All the subjects deserve my thanks for attending the experimental sessions.

Last, but not least, I must thank my family and close friends, whose apparently unlimited willingness to work hard on my behalf made everything possible.

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CHAPTER 1

NOISE AND HUMAN PERFORMANCE

1.0 INTRODUCTION AND BACKGROUND

1.0.1 Introduction

"The essential characteristic of noise is its undesirability" asserted Glorig (1958). Such a view might well have been held by the early researchers involved in studies of noise effects upon human beings and who were mainly concerned with looking for deleterious effects. The popular science literature of the 1920's and 1930's is dotted with articles describing such deleterious effects of noise in highly emotional terms, unwarranted by the facts (Berrien, 1946). Nevertheless it has now become common to define noise as 'unwanted sound' (Bell, 1966; Murrell, 1969; Rodda, 1967; Taylor, 1970). Unfortunately the definition seldom includes the basis on which the judgement 'unwanted' is made, although there seems to be certain stimulus characteristics of noise that contribute particularly to its unwantedness (Kryter, 1970). These include the masking of wanted sounds, especially speech, excessive loudness, and a general quality of 'bothersomeness'. Such a definition, though simple and wide ranging, is rather subjective and other workers in the field have proposed alternative definitions (Burrows, 1960 ; Dashiell, 1937; Dockercey, 1942; Hirsh, 1952). Nevertheless, whatever definition of noise is adopted, the fact remains that noise is sound, wanted or not, and the physical attributes of sound at least may be described in common terms (see 1.1.1.1).

Exposure to noise may result in one of three main behavioural effects. First, a temporary, or with repeated exposures over a prolonged period, a permanent and irreversible hearing loss may result; second, noise may produce feelings of annoyance and irritation; third, noise may affect the efficiency with which a variety of different tasks are performed, sometimes impairing but sometimes also enhancing, efficiency. These three effects are not necessarily related. Noise which produces hearing loss, may not impair efficiency, noise which improves efficiency may nevertheless be annoying and noise may be found acceptable even though it produces hearing loss (Broadbent, 1957).

The following noise review (section 1.1) is concerned mainly with the effects of exposure to continuous and intermittent noise upon task performance. Where appropriate, either on empirical or theoretical grounds the effects of other variables than noise, for example, sleep deprivation and heat, are also examined. Individual differences in the effects of noise upon efficiency, however, will be considered in more detail in a later chapter (see chapter 9).

1.0.2 The Development of Noise Research

The development of research into the effects of noise upon efficiency will be divided into three historical phases, following Broadbent (1970). The first phase can be considered to end about 1950, the second as lasting from 1950-1960 and the third from 1960 to the present. Although a certain amount of overlap is inevitable, the main approach to the problem of research into noise effects has been somewhat different in each phase, with the conclusions drawn concerning the effects of noise being progressively refined. Nevertheless, much of what is known about these effects upon efficiency remains to be satisfactorily explained.

1.0.2.1 Noise research up to 1950

A substantial part of the research in this phase was undertaken in industry. However, much of the research effort appears to have been wasted since the majority of these industrial studies suffered from methodological defects of various kinds. Salient among these was the 'Hawthorne effect', whereby the investigation of behaviour in an industrial setting appeared itself to exert a powerful influence on the outcome. That is, the efficiency of employees tended to increase if they interpreted a particular change introduced into their monotonous work situation as being directed at improving their welfare. Thus, while many studies of noise in industry found a reduction in noise level enhanced efficiency, some investigations also found that restoring the noise to its original level had the same effect (Broadbent, 1957a). Improvements in work performance, therefore, were not necessarily a specific response to a change in the particular variable under investigation, for example, noise or lighting level, but could possibly represent a general reaction to any modification of the work environment imposed by the investigators. Other failings of the early industrial studies included the lack of control of other variables and the use of insensitive measures of performance. Changes in noise levels were often accompanied by changes in other variables, for example, lighting or heating conditions or a move to a new building, and so any effects on performance could have been due to changes in these latter variables and not to the reduction in noise level. Also the earlier investigators employed performance measures such as output per shift or absenteeism which, with hindsight, were unlikely to show effects of noise, while neglecting to take account of those more likely to show effects such as error rates and accidents. In general, therefore, little reliable evidence concerning the effects of noise on efficiency emerges from these early industrial studies. Indeed, only one such study (Weston and Adams, 1932, 1935) was described by Broadbent (1957a) as relatively free from methodological deficiencies.

Two reviews of the effects of noise were published during this period, the first by Berrien (1946) and the second by Kryter (1950). Berrien's review was mainly concerned with industrial studies and concluded that although much of the evidence was inconclusive there were some indications that noise tended to affect work output, speed of work and certain physiological processes. Berrien also reported marked individual differences in susceptibility to the ill-effects of noise. However, apart from noting the increased unpleasantness of intermittent noise compared with steady noise, no attempt was made to differentiate the effects of intermittent and steady noise. Kryter's review was considerably more extensive and placed much greater emphasis upon the results of laboratory studies, concluding that these could be divided into three categories. Kryter considered that the first category, results demonstrating adverse effects of noise, could be largely discounted on methodological grounds and that the second and third categories, either results demonstrating slight or inconclusive effects of noise or those demonstrating that mental or motor performance was unimpaired by noise were rather more reliable.

Thus at the end of this phase of noise research, the general view of the effects of noise can be summarised in broad terms, as being that noise had not been shown to have any effect on efficiency of sufficient magnitude to warrant programmes of industrial noise reduction. However, in the light of further research, employing a wider range of tasks, which was undertaken during the next phase which lasted from 1950 to approximately 1960, certain modifications of this view were required.

1.0.2.2 Noise research 1950-1960

The second world war saw many psychologists become involved with the selection and training problems of the armed forces, the personnel of which were required to become proficient at complex tasks as quickly as possible. New tasks, many of which were simulated military tasks, were employed in the investigation of human skilled performance, and a considerable development in the understanding of skilled performance thus ensued. During the second phase of noise research, many of these tasks were subjected to the effects of noise by psychologists working both in military and civilian research settings, and it was during this period that a number of studies were successful in showing adverse effects of noise upon task performance. Although a more detailed account of the effects of noise on particular tasks will be considered later (see Section 1.1), mention will be made of one or two tasks which were found to be susceptible to noise effects. One of these, the watchkeeping task originated by Mackworth, and developed by Broadbent in England and Jerison in the United States, required the monitoring for periods of up to 2 hours of one or more signal sources for the brief appearance of infrequent and unpredictable signals which were difficult to detect. Performance, assessed in terms of the percentage of signals correctly detected, tended to deteriorate sharply after a ½hr. of work and loud noise tended to enhance this decline. A number of other studies also found adverse effects of noise on a serial reaction task (Broadbent, 1953), a complex counting task (Jerison, 1954) and on the estimation of time intervals (Jerison and Smith, 1955). Nevertheless, although performance of these tasks involving continuous information processing showed impairments attributable to noise, a number of other complex tasks failed to show any effects of noise and Broadbent (1958b) in a review of the effects of noise published towards the end of this phase attempted to explain this apparent discrepancy. His explanation emphasised distraction and predictability. He assumed that the nervous system acted to some extent as a single communication channel. Interruptions in the intake of information from one particular task source was due to the filter mechanism sampling the information from other sources, with novel stimuli having a higher probability of passing this selective filter. This tendency to sample other sources increased as a function of time on task. Obviously task performance would not be impaired if the arrival of task information was predictable, because the shifting of the filter could be delayed until the information had arrived and a response completed. If, however, the information requiring a response was unpredictable, as in vigilance situations, for example, failures to respond would be likely to increase with time at work. Broadbent considered noise to produce an effect somewhat analogous to 'blinking', but within the central nervous system. This 'blink' effect was of brief duration and produced periods of perceptual inefficiency rather than an overall reduction in the level of performance. As well as the tendency of the filter to shift away from the task more and more frequently with time at work, the number of 'internal blinks' was also assumed to increase with time at work, and thus differences between the level of performance attained in noise and quiet conditions would be enhanced towards the end of the work period. However, this effect of noise (production of brief failures of perception) could have been one of distraction in which task information is momentarily neglected, or one of paralysis, where noise would produce a temporary failure to deal with information of any kind. Largely on the basis of the results of a study (Broadbent, 1957b) concerned with the effects of noises of high and low frequency first on the serial reaction task and then using the same noises as stimuli in a reaction time experiment, Broadbent concluded that the "noise interferes with a visual task by itself controlling response rather than by disorganising all responses ... In ordinary language, the effect of noise is to cause a wandering of attention rather than a complete mental blank." (Broadbent, 1958b p. 101). That is, the distraction rather than the paralysis hypothesis appeared to be supported.

Broadbent's analysis of the effects of noise suggested that these effects would occur only if certain conditions were met. First, the task had to be one requiring continuous monitoring or information handling. Second, the task should last for a relatively long time, at least 30 minutes and preferably longer. Third, the noise level should be at least 100dB and even then effects might not be obtained if the noise spectrum contained a predominance of low frequencies. However, more recent work, to be mentioned later (Section 1.1) suggests that effects of noise on task performance can be obtained even when some of these conditions are absent. Such effects have been found at lower noise levels and with tasks of very short duration.

Nevertheless, in view of the rather specific nature of the effect found in the laboratory, it remained doubtful whether this effect of noise was of any practical importance. Furthermore, no matter how prolonged the laboratory experiments, they could not hope to involve people who were accustomed to noise as they would be in a real-life working situation. Therefore, in an attempt to validate this finding, the process of film perforation was investigated by Broadbent and Little (1960), by acoustically treating some bays and comparing performance before and after the change had been made. The sound pressure level of about 99dB before treatment was reduced to 89dB. Over the period studied, there was an improvement in the rate of work in both the treated and untreated bays, but there was no significant difference in output between the two bays. However, on one measure of quality over which operators had some control (the number of broken rolls of film attributed to the operator rather than to factors outside his control) the improvement in the treated bays was significantly better than in the untreated bays.

While not too much should be placed on the magnitude of the change, the results confirmed the prediction from the laboratory experiments that rate of work is not improved by noise reduction, except, perhaps, by a general morale factor, but that human error is less frequent when the noise level is lower. Along a similar vein, another industrial study (Kerr, 1950) reported a significant correlation between accident rate and noise level. Thus it seems that noise effects on efficiency also appear in individuals who are accustomed to noise and who have had plenty of experience in the work situation.

Towards the end of this second phase, another review of the psychological and physiological effects of noise, which was mainly concerned with American work during this period, was published by Plutchik (1959). He put forward three main points concerning the effects of noise on performance. First, he suggested that performance impairments are more likely to occur during high intensity intermittent sound than under lower intensity or steady sound. Second, he pointed out that the relative difficulty of a task is an important variable determining the effect of noise on performance. The more difficult the task, the more likely will noise be disruptive. Third, he considered that even though individual differences in response to noise were extremely important, they had received little systematic investigation, but that future focussing of attention in this area might be of use in explaining some of the discrepancies in the research on the effects of noise upon performance.

It had thus become clear, by the end of the second phase of noise research that certain tasks, particularly those demanding continuous attention and information processing, were susceptible to the effects of noise and Broadbent's 'internal blinks' hypothesis was the principal explanation put forward to account for these generally detrimental effects. During the next period of research, from 1960 onwards, the number of studies concerned with the effects of noise upon performance increased. More attention was given to the role of individual differences, to the effects of different types of noise in combination with other stresses and consequently certain modifications in the hypotheses concerning noise effects upon performance were required in the light of these studies.

1.0.2.3 Noise research since 1960

A continuing theme of the third phase of noise research has been the attempt to elucidate the mechanism mediating the effects of noise upon efficiency. At the beginning of this phase a number of studies were conducted which made detailed comparisons of the effects of noise and those of other stresses such as loss of sleep and high ambient temperatures upon the performance of tasks requiring continuous attention. The changes in efficiency that occurred under the simultaneous administration of two stresses were also examined (Poulton, 1966; Wilkinson, 1969).

From this work arose the "arousal theory of stress" (Broadbent, 1963a; 1971) which assumes that there is a general state of arousal or reactivity which is increased by incentives or by noise and reduced by loss of sleep or boredom. It further assumes that inefficiency is high when arousal level rises beyond an optimal point, which is probably related to the chronic arousal level of the individual performing the task and to the demands of the task itself. Inefficiency is also assumed to be high when arousal level is too low. Thus, the relationship between level of arousal and level of efficiency is considered to follow an inverted - U. In some respects, this version of the arousal model is too simple and does not satisfactorily account either for the effects of all stresses or for all aspects of the experimental results obtained. One difficulty has been that the effects of high temperatures are not easily accommodated by such a model, although recent research (Poulton and Edwards, 1974; Poulton, Edwards and Colquhoun, 1974) has shed further light on this problem. A further problem has been the nature of the errors at high levels of arousal, although once again more recent work (Hockey, 1970a, b, c, 1973) has helped to clarify this point. Further mention of the arousal theory of stress and its difficulties will be made later. (See Chapter 2).

Noise research in this phase has also been influenced by the Theory of Signal Detection (Tanner and Swets, 1954), which has provided a new framework for the description and analysis of human performance. McNicol (1972) observes that the relevance of signal detection theory to psychology, and hence to human performance, is that it is a theory concerned primarily with the way in which decisions are made, and in particular with decisions based on evidence which does not unequivocally support any one of a range of possible decisions. A number of measures of performance which can be applied to decision-making situations are provided for by the theory, for example, whether or not a signal has been presented in a vigilance task. McNicol states, "Essentially the measures allow us to separate two aspects of an observer's decision. The first of these is called sensitivity, that is, how well the observer is able to make correct judgements and avoid incorrect ones. The second of these is called bias, that is the extent to which the observer favours one hypothesis over another independent of the evidence he has been given. In the past these two aspects of performance have been confounded and this had led to mistakes in interpreting behaviour" (1972, p 11). The measure of sensitivity is known as d' and the measure of bias as β. As far as noise research is concerned, the principal outcome of the utilisation of signal detection theory in the analysis of human performance has been the development of a new explanation of the effects of noise on vigilance (Broadbent, 1971; Broadbent and Gregory, 1963, 1965) although a recent study (Schwartz, 1974) has extended this analysis to short-term memory.

Further work on individual differences in the effects of noise on performance was undertaken during this period. Physiological responses to noise and their relation to efficiency were also examined, but much research is still needed in these areas before these effects are fully understood.

A new area of study in this phase of noise research has been the introduction of noise as a factor in broader studies of interpersonal, social and general adaptive behaviour (Bull et al., 1972; Konecni, 1975). These studies are of a rather different kind than the performance of abstract tests, but they provide illustrations of the way in which noise effects on performance may show themselves. Glass and Singer (1972), in their monograph emphasised the importance of cognitive variables in determining noise effects, following up some observations made in a paper by Azrin (1958). They showed that the context in which noise occurs is a more critical determinant in producing adverse after-effects than are the physical characteristics of the noise. For example, adaptation to unpredictable, in contrast to predictable, noise resulted in lowered tolerance for subsequent frustrations and impaired performance on a proof-reading task. However, this effect was not so great if subjects thought they had control over the noise. Similar findings have also been reported in more recent studies (Wohlwill, Maser, DeJoy and Foruzani, 1976; Hiroto and Seligman, 1975; Miller and

Seligman, 1975). Nevertheless, after-effects of noise, and of other stresses, have been relatively neglected in noise research, although besides being of practical importance they are extremely relevant to the explanation of the effects of noise on efficiency (Hartley, 1973). Further findings from the studies of noise effects on social and interpersonal behaviour have suggested, broadly, that noise seems to produce more vigorous behaviour in response to the dominant features of a situation rather than to the minor ones (Geen and O'Neal, 1969; Geen and Powers, 1971; Matthews and Canon, 1975).

Two reviews published during this period not only provide useful progress reports on the research area but also illustrate the range of disagreement between researchers in the field. Broadbent (1971) contrasts current views of noise effects with those in his earlier book, "Perception and Communication" (1958). He discusses some of the problems concerning a unitary concept of arousal and proposes, in his final chapter, a two-stage arousal model which attempts to cope with the problems faced by less complex arousal models.

The other review (Kryter, 1970) concludes very differently. After a thorough examination of the experimental evidence, Kryter concluded that "... other than as a damaging agent to the ear and as a masker of auditory information, noise will not harm the organism or interfere with mental or motor performance. Man should be able, according to this concept, to adapt physiologically to his noise environment, with only transitory interference effects of physiological and mental and motor behaviour activities during this period of adaptation" (Kryter, 1970, p 587). Thus, Kryter's view appears to be that there are no direct effects of noise on performance at all, except those that may occur in the course of adaptation to noise. Where such effects have been reported, they can be attributed to indirect effects of noises such as the masking of task-relevant auditory cues (see also Stevens, 1972 and Poulton, 1977). This view is perhaps better expressed in Kryter's own words, "Because of adaptation, one could anticipate that regular, expected noise may in general have no adverse effects on non-auditory mental or motor work performance or output. Indeed, in our opinion, the experimental data ... show this to be the general fact of the matter. This general conclusion is not shared by D E Broadbent, who has been a major contributor to the fund of research data and theory on the effects of noise on the mental and motor performance of man" (Kryter, 1970, p 546).

Following this general outline of the three phases of noise research, attention is directed to a survey of the effects of noise on the performance of different tasks. However, preceding this is a discussion of some of the principal methodological problems inherent in such research.

1.1 The Effects of Noise on the Performance of Different Tasks

1.1.1 Methodological Considerations

Many problems are involved in the collection and interpretation of data concerned with the effects of noise on efficiency, and these may be classified under four headings, the measurement, specification and presentation of experimental conditions, the selection of subjects, the design of noise experiments and the assessment of performance.

1.1.1.1 The measurement, specification and presentation of experimental conditions

Noise impinges upon man through the arrival at the tympanic membrane of the ear of a sequence of air pressure changes due to successive waves of compression and expansion of the medium through which the waves travel. The degree of compression-expansion of the medium and the frequency with which it occurs determine the basic components of the physical characteristics of auditory stimuli, the amplitude being reflected in the maximum degree of compression of the air from which sound pressure values are measured in Newtons/sq. metre and the frequency of the cycles of compression-expansion per unit time i.e. cycles per second or Hertz (one Hertz is equal to 1 cycle/sec.). The audible frequency spectrum of the human ear spans roughly 20-19000 Hz. Since sounds are seldom made up of only one frequency, unless they are 'pure' tones, noise of mixed frequencies, taken from a wide range of the frequency spectrum has become known variously as 'broad band noise', 'wide spectrum noise' or 'white noise', although for noise to be truly 'white' the constituent frequencies need all to be of the same intensity. Noise in which the constituent frequencies are predominantly high or low has similarly been labelled 'pink' and 'green' respectively.

The intensity of a noise is not usually described in terms of the physical properties of the stimulus but in terms of a ratio of the sound pressure level (SPL) of the noise to an arbitrary SPL (usually .00002 N/sq. metre). Because of the wide range of pressure variations to which the human ear is sensitive, a logarithmic scale is used to compress the range, and this is then divided into units of one tenth of the basic unit (Bel) to give the final scale a range of approximately 140dB.

The faintest sound that can be heard (the auditory threshold) varies with the frequency of the sound. The sensitivity of the human ear for binaural listening in young adults is very near to the reference level (0dB) for frequencies between 1000 and 4000Hz although at 250Hz it is between 20 and 40dB and at 30Hz between 70 and 80dB. The thresholds of discomfort (120-140dB) and pain (above 140dB) are independent of frequency, however.

In order to take account of the influence of frequency characteristics on the noise intensity of pressure levels several modifications of the decibel scale have been suggested that give a differential weighting to the intensities of noise stimuli in various frequency bands and most sound level meters contain weighting networks which can be activated to reduce the response of the meter to low frequency and very high frequency sounds, thus simulating the response of the human ear. There are three main types of weighting, yielding SPL values in terms of dB A, dB B, dB C although the former is probably used most frequently in experiments on noise and efficiency, since its weighting corresponds most closely to the response of the ear. The A, B, and C weightings vary principally in the degree of sensitivity provided at lower frequencies relative to the sensitivity at 1000Hz in terms of the indicated SPL for a given sound. Of the three scales, the A scale provides least sensitivity at low frequencies, while the C scale provides most, with the B scale occupying an intermediate position.

Most of the reviewers of the research literature have noted inconsistencies in the results obtained by different experimenters. A closer inspection of the individual studies, however, reveals a lack of standardisation between the different experiments.

Several types of sound generators have been employed in the study of noise effects on performance. Many experimenters (Auble and Britton, 1958; Glass, Singer and Friedman, 1969; Chatterjee and Krishnamurty, 1972; Hanley and Williamson, 1966) produced a tape or phonograph recording of some common noise, which was then electronically amplified to the desired loudness, the recorded noise being that of a factory, street, traffic, music, jet engine, depending upon the particular focus of the research. In this method of sound generation, there is no direct control over the composition of the noise, and in order to overcome this problem, electronic generators have been utilised by more recent experimenters to produce either pure tones (Harris, 1968; Diespecker and Davenport, 1967) or so-called 'white noise' (Barnett, Ellis and Pryer, 1960; Harris, 1972), a random combination of frequencies from all or most of the audible spectrum, with approximately equal intensities across all frequencies.

One of the most often considered parameters of a noise is its intensity, although many of the earlier experimenters (Morgan, 1916; Cassel and Dallenbach, 1918; Tinker, 1925) did not describe sound exposures in terms of physical energy measurements: they merely described the sound sources, for example, buzzers, bells, firegongs. In the majority of more recent studies, maximum levels of 90-110dB have been employed, although levels of 130-140dB have occasionally been used (Harris, 1968).

The minimum requirements of an experimental investigation into noise effects is that there should be a noise condition and a control condition with which it is compared. In most investigations this latter condition, generally known as the 'quiet' condition has taken the form of (i) 'silence', presumably meaning ordinary room noise, which, unless the experimental chamber is sound attenuated, may be expected to reach levels of between 50 and 60dB; (ii) a level of noise 'just sufficient to mask ambient noises in the experimental situation or (iii) a level of noise rather higher than this. A reference noise level of about 70dB commonly represents the 'quiet' condition in most experiments, although in at least one study 'quiet' is specified as being as high as 90dB (Stevens, 1941) whereas in another, the 'noise' is specified as low as 50dB (McCann, 1969).

'Quiet' is thus a relative condition and not one with zero ambient noise, although at least one study, Theologus, Wheaton and Fleishman (1974) specifies a quiet condition of 0dB. However, as Davies (1977) points out, "The specification of the noise level to be used as a control condition gives rise to two problems. First, there may be differences in the effects of different control levels of noise on performance and second, the difference between the noise levels used as experimental and control conditions may influence whether or not effects of noise on performance are obtained. For example, it may be the case that on some tasks there will be no significant effect on performance of a noise level of 100dB compared to a control level of 70dB, whereas there is one if the control level is kept down to 55dB" (Davies in press).

The first problem has been examined by several experimenters, who have usually compared performance under a range of noise intensities. Blackwell and Belt (1971) compared the effects of three levels of white noise, 50dB, 75dB and 90dB upon performance of a single source vigilance task and found no differential effects. Along with similar findings by Berlyne, Borsa, Craw, Gelman and Mandell (1965) and Hanley and Williamson (1966), these studies suggest that for some tasks, the level of the control condition could lie within a range of intensities and yet produce similar results. However, an apparently inconsistent finding was reported by Eschenbrenner (1971) who found significant differences between each of three intensity levels (50, 70 and 90dB) on image motion compensation performance. A possible reason for this discrepancy would be the differing levels of complexity of the tasks involved, a view receiving support from the results of Heimstra (Heimstra, 1972).

The second problem noted by Davies, that the difference between the noise levels used as experimental and control conditions may influence whether or not effects of noise on performance are obtained has not been adequately investigated. A final point concerning the control or 'quiet' condition is that some studies have not even employed such a condition. These, however, have mainly been studies investigating the effects on performance of different types of auditory backgrounds at the same intensity (Davenport, 1972, 1974), although some studies comparing 'varying' with 'steady' noise have also lacked a control condition (Kirk and Hecht, 1963).

Another important characteristic of noise which could influence the particular effects on performance which are obtained, is that of frequency. Many investigators have used broadband or white noise or an approximation to this, such as machinery or aircraft noise (Stevens, 1941), but some have used pure tones (Harris, 1968) while others have deliberately varied the frequency of the noise. In a comparison between high and low frequency noise at different intensity levels Broadbent (1957b) found that performance on the five-choice serial reaction task in 100dB high frequency noise was significantly worse than that in low frequency noise at the same intensity. At lower intensities, however, no significant differences between high and low frequency noise were apparent. More recently, Poulton and Edwards (1974) using low frequency noise demonstrated effects on the five-choice serial reaction test not noted in ten previous studies of noise on this particular task and they concluded that the differences may have been due to the different spectra of the noises.

Clearly noises may be of different frequencies and intensities, but another important distinction to be made is that between continuous and intermittent noise. The latter may be characterised by regularly occurring silent intervals and noise presentations and its affect upon performance appears to be related to its 'on-off' ratio, i.e. the total percentage of the time the noise is on relative to the time it is off. Teichner, Arees and Reilly (1963), utilising ratios of 30, 70 and 100% observed a significant effect of noise on the speed of visual target detection except for the 70% ratio which was considered to be a neutral point. Heimstra (1972) examined variations in task complexity, noise intermittency and noise intensity and concluded that the neutral ratio depended upon the interaction of these factors. Obviously intermittent noise need not be periodic, since the noise-silence intervals may be completely random, in which case the noise is usually referred to as aperiodic intermittent noise, and differential effects on performance of periodic and aperiodic intermittent noise have been reported (Eschenbrenner, 1971).

Finally, the mode of presentation of the noise has not always been constant. The majority of recent researchers have presented noise either via head-phones or loud-speakers and perhaps these different modes of presentation may account for some of the inconsistencies in the literature, although this seems unlikely in view of the findings of Hartley and Carpenter (1974) who obtained no significant differences between the two types of noise presentation on the three principal measures of performance on the five choice serial reaction test. However, a tendency was observed for head-phone noise to have a greater effect on errors. One or two possible explanations advanced to account for this are that firstly, noise presented in the free-field is considered to be perceived as louder than noise of the same SPL presented over head-phones (Kryter, 1970) while noise presented over head-phones provides a "less variable and more coherent input" than free-field noise and secondly that head-phone noise is more likely to mask sounds generated by the experimental apparatus and the subject himself than is free-field noise.

Ear-defenders have also been used in a few studies. Woodhead (1960) examining the effects of high and low frequency intermittent noise on performance at a visual inspection task of brief duration, found that ear-defenders significantly reduced the adverse effects of noise in the case of high frequency bursts. Hartley (1974) however, noted that although ear-defenders had no overall effect on either the overall rate of responding or on the error rate on the five-choice serial reaction test, they did reduce the adverse effects of noise on the rate of work in the first half of the task. Hartley attributed the beneficial effect of ear-protection to a reduction in perceived loudness and a prevention of temporary arousal following the onset of noise.

It was noted in 1.0.2.3 that the context of the experiment in which subjects are exposed to noise may well be important in determining noise effects. In particular the degree of control that the subject perceives himself as having over the noise to which he is exposed may influence his performance. It has usually been implicitly assumed that subjects regard the noise to which they are exposed as unavoidable. However, when subjects are instructed that the noise can be avoided by simply pressing a button, this degree of perceived control over the exposure to noise has been shown to be an important determinant of the amount of 'stress' experienced and the level of performance achieved under noise (Glass, Singer and Friedman, 1969). Similarly, the subject's instructional set has also been shown to exert an influence on the obtained effects of noise (Baker, 1937; Mech, 1953).

In conclusion, many factors, some of which are not usually controlled, are involved in determining the effects of noise on performance and because of the lack of standardisation in the specification and presentation of the experimental conditions generalisations about noise effects remain difficult to make with any great degree of confidence.

1.1.1.2 The selection of subjects

In many areas of psychology a very large percentage of experimental subjects are University students, many of whome come from introductory psychology classes (Jung, 1969; Schultz, 1969). There is frequently a course requirement to participate as subjects and therefore students are not always volunteers. Davies (1977) suggests that this probably results in the samples being more representative of their population than they would otherwise be, although presumably there are other less advantageous effects. Students have probably served as subjects in the majority of studies undertaken in universities, while research conducted in non-university research units has frequently employed personnel drawn from the military services. Generally, the subjects used have been under 30 years, and the study of the effects of noise on the performance of older subjects has been almost completely neglected apart from one recent study (Davies and Davies, 1975) which has examined such effects. Subjects are often required to undergo a hearing test before participating in an experiment and if they possess a hearing loss beyond some criterion point, usually around 35dB, in one or both ears, they are rejected.

1.1.1.3 The design of experiments

Two principal experimental designs have been employed in noise research. One uses independent groups who are either matched on what are considered to be relevant characteristics or on prior performance, or are randomly allocated to the various treatment groups. The other, a repeated measures design, tests subjects under all treatments, assigning one or more subjects to each of the possible treatment orders. As long as adequate numbers of subjects are used (see Poulton, 1970) then there can be little objection to the use of the independent groups design provided that either the random allocation of subjects to treatment groups is justified, possibly on the basis that the task is so simple and/or familiar that there is likely to be little variation in the ability of subjects to perform it, or care is taken to match the subjects in the various treatment groups so that they do not differ in their ability to carry out the assigned task.

However, a number of difficulties with the repeated measures design have been noted by Poulton in recent publications (Poulton, 1970, 1973, 1974; Poulton and Freeman, 1966). The possibility of transfer is probably the major problem faced by this design. When a subject performs the same task under two or more treatments, it is possible that the treatment in which he first encounters the task may influence his performance not only on this first occasion, but also when the task is subsequently carried out in another treatment condition. Transfer effects may be symmetrical or asymmetrical, and the asymmetrical transfer effect may operate in both possible directions, or in only one. An example of a symmetrical transfer effect would be where Group 1 proceeds from treatment A to treatment B, while Group 2 proceeds from B to A, and an improvement (for example, with practice) or a deterioration (for example, with fatigue) of similar size is found in both groups from the first to the second treatment. When the transfer effect is symmetrical, neither the difference between the total scores of the two groups nor that between the totals of the two conditions is affected. However, when the transfer effect is asymmetrical, the amount of improvement or deterioration differs depending upon the order in which the two conditions are met. An example of a one-way asymmetrical transfer effect would be where the performance level of Group 1 remains unchanged over the two treatments, whereas that of Group 2 shows a marked rise, or fall, under treatment A. A two-way asymmetrical transfer effect occurs when the direction of the performance change is influenced by the order in which the conditions are encountered. For example, the performance level of Group 1 deteriorates while that of Group 2 improves. Both these transfer effects can act either to increase or decrease the differences between the experimental treatments, but in either case, the sensitivity of the experiment is reduced. A number of studies showing asymmetrical transfer effects, including some concerned with noise, were examined by Poulton and Freeman (1966) who concluded that such effects generally reduce differences between experimental treatments, sometimes resulting in no overall effect of the variable of interest (e.g. noise) being found. When a subject performs under the stress condition first, followed by the control condition, the strategies employed to cope with the task under stress appear to be carried over to the control condition and this results in a lower level of performance than expected. Similarly, the level of performance under stress after working first in the control condition is sometimes higher than would be expected. It has been suggested that separate statistical comparisons on the conditions performed first and those performed second should improve the sensitivity of such experiments. Where practice is thought to be responsible for an asymmetrical transfer effect it is important to make sure that subjects are well-practised on the task until performance has stabilised before the stress condition is introduced. This procedure was adopted by Cohen, Conrad, O'Brien and Pearson (1973) who found an effect of noise and could therefore conclude that their results indicated an effect upon performance rather than upon learning. Unstabilised performance scores also tend to show larger variations than stabilised scores. In addition to the effects of previous experience with the task, those of acclimatisation or adaptation to the stress have been shown to exert an influence upon the magnitude of the particular effect obtained (e.g. Wilkinson, 1969). Another problem of the repeated-measures design is the possibility of range-effects, where a subject's responses are influenced by the range of stimuli, or the range of his responses, or both (Poulton, 1973, 1975).

Since transfer or range effects may be operating in repeated measures designs, the choice of experimental design in stress research could be an important determinant of whether or not an effect of stress is observed. It is possible that failures to obtain effects of noise on performance in some noise experiments which have used a repeated measures design could be attributed to the particular experimental design employed. Furthermore, where effects of noise have been obtained using a repeated measures design they may well be spurious unless other studies employing independent groups of subjects have replicated the results. It would thus seem appropriate in reviewing the effects of noise on performance to place more reliance on results using independent groups of subjects.

1.1.1.4 The assessment of performance

When a stress is observed to exert no significant effect upon performance, it may be that performance is genuinely unaffected by the stress or that the measure of performance selected is insufficiently sensitive to its effects. Both Poulton (1965) and Wilkinson (1969) discuss a number of factors that should be taken into account in order to make a task maximally sensitive to environmental effects. These include the difficulty and duration of the task, as well as the necessity of examining closely all aspects of task behaviour.

Another problem which acts as a deterrent from making generalisations about noise effects is that, at present, there is a lack of a set of unifying dimensions underlying skilled performance. For a number of years, psychologists have called for a method of classifying tasks - a task taxonomy - not only one of finding ways to generalise principles from one task to another, but one that also enables generalisations of findings from laboratory studies to the applied field. Not long ago, the favourite distinction was between 'motor' and 'mental' tasks or between 'cognitive' and 'non-cognitive' tasks but such distinctions have obvious limitations. A more recent approach has been to categorise tasks in terms of classes of functions. For example, Gagne (1964) used categories like discrimination, identification of cues, interpretation and decision-making. However, a different approach was employed by Alluisi (cited by Fleishman, 1967) who classified tasks as 'vigilance' tasks, arithmetic tasks, pattern comparison tasks and so on. Nevertheless, at the present time, no taxonomy of laboratory tasks exists which would enable a clear picture of the performance functions affected by noise to be obtained. Therefore, in considering noise effects upon different types of tasks, tasks which bear some degree of resemblance to one another are grouped together under such headings as 'intellectual' tasks and 'psychomotor' tasks in a similar manner to that adopted by Grether (1971) and the remainder of this section presents a summary of the effects of noise upon performance at these different types of task. The tasks are reviewed in alphabetical order.

1.1.2 Intellectual Tasks

One of the first ideas of most investigators of noise is that one should measure performance using a paper and pencil test of intellectual function, such as an intelligence test or a series of problems in mental arithmetic. The score of such a test is usually the total number of problems solved or perhaps the number of errors. It is to this type of task that the present section is devoted and it is divided into four main categories: 1) tests of clerical ability; 2) coding and sorting tasks; 3) arithmetical tasks; 4) standard intelligence tests. As Grether (1971) has pointed out, the first category contains many tasks whose demands appear to be primarily perceptual, rather than intellectual, although since investigators using such tasks have usually labelled them as intellectual tasks, this classification will be retained here. But in many respects such tasks as letter, name or number-checking, or pattern matching can be considered as more closely resembling the cancellation tasks discussed below under the heading 'monitoring and inspection tasks'. The second category contains tasks such as card-sorting and various coding tasks, while tasks in the third category are those involving arithmetical calculations. The fourth category contains standard tests of intelligence or general mental ability such as the California Capacity Questionnaire and the Otis Self-Administering Tests of Mental Ability.

1. Tests of cerlical ability

The effects of noise on the performance of clerical tasks appear to be slight, although studies employing continuous and intermittent noise have produced somewhat conflicting results.

Wilbanks, Webb and Tolhurst (1956) examined the effects of recorded aircraft noise presented continuously at a level of 110-114dB upon the performance of four tests drawn from the Differential Aptitudes Test (mechanical reasoning, abstract reasoning, clerical speed and accuracy, and numerical ability). The noise was in fact relayed through head-phones reaching a SPL at the ear of 106dB. Two groups of 46 naval cadets performed these tests in both noise and quiet ('reasonably normal sound conditions'), one group receiving the noise condition first and the other quiet. Testing took about three hours to complete. Only on the clerical speed and accuracy test was any effect attributable to noise obtained, performance being significantly enhanced under noise.

Smith (1951), on the other hand, was concerned with the effects of intermittent noise (unpredictable bursts at 100dB, with an on-off ratio of 50%) upon performance on the Minnesota Clerical Test (number checking and name checking) and the Revised Paper Form Board Test (series AA). Significantly more items were attempted on the Paper Form Board in noise, while on the name-checking test, the percentage of items correct was significantly lower in noise. Smith concluded that on the three tests generally, extraneous noise tended to encourage productivity and to discourage accuracy, but these effects were of such magnitude as to suggest that they were practically negligible. However, Auble and Britton (1958) using continuous noise but at a lower intensity (80dB) and a similar kind of task as Smith (although the task duration was 60 min. as opposed to the 30 min. used by Smith) found no effect of noise on clerical performance.

The above studies have employed a total testing time of between half an hour and three hours, whereas a study by Hanley and Williamson (1966) investigated the effects of constant and varying noise upon the performance of three very short, simple clerical tasks. Subjects performed n arithmetical addition task (5 min.), a short vocabulary test ($1\frac{1}{2}$ min.) and a number comparison test (3 min.) in a constant noise (recording of a battery of office machines) level of 65, 75, 85 or 95dB or in a variable noise condition, which consisted of a random presentation of the above conditions in a predetermined schedule. A control condition of 'no-noise' was also employed. Results indicated that intensity of noise was not systematically related to proficiency in performance in the three tests, although for the addition task, the level of performance tended to decrease with increasing noise level, but not significantly so. The comparison between a constant noise condition and a varying one also revealed no statistically significant differences. Clerical tests, therefore, appear relatively unaffected by noise, although some increase in speed in both continuous and intermittent noise has been noted.

2. <u>Coding and sorting tasks</u>

Results of studies employing coding tasks have generally showed no significant effects of noise. Morgan (1916) employing a task involving two encoding operations on a presented letter noted an initial decrement in noise which soon disappeared. Similarly later work (Stevens, 1941; Houston, 1968) produced similar results. In a very thorough study of the effects of noise on a variety of tasks, Stevens failed to find any significant differences between noise (115dB) or 'quiet' (90dB) on either a coding task, which required subjects to translate written material into code, letter by letter, for $1\frac{1}{4}$ hours or on a card-sorting task.

Houston (1968) employed a much lower noise level (78dB) in his investigation of the effects of noise on the Digit Symbol Test, a subtest of the Wechsler Adult Intelligence Scale (Wechsler, 1958) which requires the substitution of symbols for digits in accordance with a code and lasts for approximately $1\frac{1}{2}$ minutes. A slight, though not significant, improvement was observed in noise compared with a quiet condition consisting of normal room noise.

Thus coding and sorting tasks appear to be relatively unaffected by noise, although it should be noted that the lack of any effects of noise in the two latter studies could possibly be due to the rather high noise level of the 'quiet' condition (90dB) in Stevens' study and the low 'noise' level (78dB) in Houston's study. However, Cohen, Hummel, Turner and Dukes-Dobos (1966) employing more conventional noise levels (noise 105dB, very quiet 75dB) reported similar results, i.e. no effects of noise, on anagram solution.

3. Arithmetic tasks

Early studies of the effects of noise upon tasks involving mental arithmetic have generally failed to find any significant effects of noise (Obata et al., 1934; Vernon and Warner, 1932) although a tendency for a temporary decrement in noise was noted by some investigators (Ford, 1929; Harman, 1933). Similarly, an arithmetical task (division) thought to be unchallenging by Park and Payne (1963) was unaffected by noise at a level of 98 - 108dB compared with quiet (50 - 70dB). Subjects worked at 'easy' or 'difficult' problems for 20 minutes in noise or quiet and although no significant effects on mean performance were observed, nevertheless noise was found to increase the variability of performance for subjects working with 'easy' problems, but no such effect was obtained with subjects working with 'difficult' problems.

A more recent study, Nuckols (1969) using arithmetical problems was also concerned with the effects of prior conditioning in noise. He found that 85dB noise (consisting of inter-station noise from a short-wave radio receiver) impaired performance significantly at a task requiring the solution of algebra problems when subjects had been exposed to the noise for 40 minutes prior to commencing the 20 minute task. However, performance was not impaired by 100dB noise either without prior exposure or following a 20 minute pre-task exposure period. The quiet condition in this study was the same noise relayed at 52dB. This finding is consistent with the results of research demonstrating that the duration of noise exposure is an important determinant of the effects of noise on performance (Hartley, 1973) but it is unclear why the higher intensity noise did not also produce adverse effects on performance. It is unfortunate, too, that the 100dB noise condition was not employed in conjunction with a 40 minute prior exposure period. Obviously further investigation of the effects of the duration of prior noise exposure and of noise intensity on performance at this type of task would appear to be required.

On the whole, therefore, it seems that noise exerts little influence on the performance of conventional mental arithmetic tasks. However, when such tasks are made more difficult by the inclusion of a short-term memory (STM) component, adverse effects have been consistently obtained. Following on from the results of Jerison (1954; 1956) which indicated that a complex counting task involving a STM component was impaired in noise, Broadbent (1958a) devised an arithmetical task involving such a component. This comprised a self-paced subtraction task in which subjects observed a 6-digit number, memorised it, and subtracted from it a 4-digit number. Thirty such problems were presented during a session which lasted approximately 15 minutes. Eighteen subjects were divided into three equal groups - one (QQ) worked in 70dB noise on both days, another (QN) worked in 70dB on the first day and 100dB on the second day, and a third group (NQ) worked in 100dB on the first day and 70dB on the second. Results on the first day of testing indicated that subjects working in noise showed a greater deterioration, in terms of the time required for calculation than those working in quiet. Furthermore, on the second day of testing, the group originally tested in noise also showed the greatest deterioration in quiet. The second group, who received the noise condition second, also showed greater within-session deterioration than the group tested in quiet on both occasions. In this study, therefore, speed of work was significantly impaired in noise towards the end of the work period and, in addition, an after-effect of noise was obtained, which may be attributable to asymmetrical transfer (Poulton and Freeman, 1966). Broadbent's findings were largely confirmed by Harris and Sommer (1971) who examined the effects of a combination of noise and vibration upon the performance of a shortened version of the same task. Vibration (0.25g (peak) vertical vibration at 5Hz) in combination with low level noise (80 and 90dB) had no significant effect on performance, although vibration in combination with 110dB noise produced a significant reduction in the number of correct responses. In a second experiment, it was found that high intensity noise (107dB) and vibration combined to produce a greater decrement in performance than either condition alone. Noise and vibration thus appear to summate in their effects on efficiency at this task. Finally, Woodhead (1964a), again using the same task but intermittent noise, showed that the presentation of 100dB noise bursts during the period that the 6-digit number was being presented, exerted a much more adverse effect upon subsequent performance than the presentation of noise bursts during the calculation period. The latter condition produced little effect upon error rates but significantly increased the speed of work.

Thus, when mental arithmetic tasks involve a STM load, they appear to become susceptible to the effects of noise. It might also be expected from work with monitoring tasks, that performance at a multi-source arithmetical task would be more adversely affected by noise than performance at a single source task. In a test of this hypothesis Samuel (1964) compared the effects of noise (110dB) and quiet (80dB) on performance of a dual-source addition task. Four independent groups of 5 men and 5 women worked in noise or quiet and performed a 21 minute mental addition task in which the two digits to be added were either presented at the same source or on two spatially separated sources. Contrary to expectations, the percentage of errors was significantly lower in noise in the spatially separated condition and fewer omissions were made. In the same source condition, no difference was found between noise and quiet. Noise did not appear to impair the process of calculation itself and Samuel concluded that "either the perceptual or the effector mechanism ..... is affected by noise" (p. 266).

Samuel noted certain differences between his task and the multi-source tasks in which performance is impaired by noise. He suggested that his task was simpler, less highly paced, and placed a smaller load on STM. Nevertheless, the reason why Samuel's results are different from those usually obtained with multi-source tasks is not clear and it would seem that further investigation is required.

4. Standard intelligence tests

Results of studies examining the effects of noise on intelligence tests have generally been consistent with those of early investigators who found performance to be unimpaired under noise (Tinker, 1925; Hovey, 1928). For example Stambaugh (cited in Corso, 1952) examined the effects of noise at 105dB on performance on the California Capacity Questionnaire and concluded that high intensity noise did not affect mental functional capacity. However, Blau (also cited by Corso, 1952) using the Otis Self-Administering Test of Mental Ability found that although there was no significant difference between performance in noise (103 $\pm$ 2dB) and that in quiet (50 $\pm$ 10dB) in the number of items correct, there were significantly more incorrect items in noise than in quiet, implying that subjects completed more items in noise but were less accurate.

In conclusion, therefore, it would seem that noise exerts little or no effect on the performance of intellectual tasks unless a STM component is involved.

1.1.3 Memory and Verbal Learning

From its earliest years, an important part of experimental psychology has been the study of factors affecting the acquisition and retention of verbal materials. Current research on human memory is generally divided into two main areas, one concerned with short-term memory (STM) and the other with long-term memory (LTM). STM studies have usually taken the form of presenting a list of items, such as words or digits, to a subject and requiring the recall of the whole list as soon as it has been presented. LTM studies have normally required subjects to learn a list of items to some criterion, followed by a subsequent retention test of the material some days or even weeks later. As Cermak (1972) points out, STM studies are concerned with factors affecting the retention of underprocessed and unrehearsed information, while LTM studies are concerned with the retention of material that is both fully processed and well rehearsed. Stemming perhaps from suggestions by Jerison (1959) to the effect that STM might be impaired by noise, a number of noise studies have attempted to examine possible effects on both ST and LT memory.

Early studies did not suggest that memory was greatly affected by noise, but as Schwartz (1973) indicates, a number of different types of result have emerged from later studies of the effects of noise on memory and verbal learning, or more broadly, of the relation between learning, memory and arousal. The first type of finding is that the introduction of noise during the presentation of a list of to-be-remembered items, or during the retention interval just prior to recall, has been shown in some cases to exert an effect both on STM and on LTM. The effects of noise on STM appear to be conflicting, since some studies suggest that noise improves immediate retention (Archer and Margolin, 1970; Wesner, 1972), others that immediate retention is impaired by noise (McLean, 1969) and others that noise exerts no effect upon immediate retention (Sloboda, 1969; Sloboda and Smith, 1968; Baumeister and Kistler, 1975). LTM appears generally to be improved by the presence of noise during the original presentation of the material to be learned (Berlyne, Borsa, Hamacher, and Koenig, 1966; McLean, 1969) or during the retention interval just prior to recall (Uehling and Sprinkle, 1968; Baumeister and Kistler, 1975), although, in one study, noise during recall exerted no effects on LT retention (Berlyne, Borsa, Craw, Gelman and Mandell, 1965). However, these studies will be considered in more detail later (see Chapter 2).

A second type of result suggests that noise affects the allocation of attention in STM situations. In an experiment by Hockey and Hamilton (1970), for example, possible changes in attention allocation to relevant and irrelevant task components were investigated. Subjects, who worked either in noise (80dB) or in quiet (55dB) were shown a series of eight words, which were projected, one at a time, on to a screen, and were subsequently asked to recall them in the correct order. The irrelevant cue was that the words were presented in different corners of the screen and subjects were not informed of this. After subjects had completed their recall of the words, they were reminded that the words had been presented in different locations and were asked to indicate the appropriate location for each word. Hockey and Hamilton found that there was no difference between the noise and quiet groups in the number of words recalled, irrespective of order, although the ordered recall scores of the group working in noise were superior to those of the quiet group (the comparison just missing significance at the .05 level). However, the recall of locations by the noise group was significantly worse than that of the quiet group. These findings were interpreted as evidence for increased selectivity in noise, attention being allocated to the high priority task component (word order) and away from the low priority component (locations) to a greater extent in the noise group. A similar finding was also obtained by O'Malley and Poplawsky (1971). Subjects, who worked in noise (75, 85 or 100dB) or quiet ('no-noise') were instructed to learn a list of six four-letter words which were presented visually, one at a time, in the centre of the screen. Additional words appearing in the corners of the screen were also presented. After the subject had reached the criterion of two consecutive errorless trials for the list of six central words, he was required to recall as many of the other words as possible. No significant differences in the number of trials required to reach the criterion were found between the different experimental conditions, but significantly more peripheral words were recalled in the 75dB and 'no-noise' groups than in the other two groups. The results of these two studies are in broad agreement with these obtained from multi-component monitoring situations (Hockey, 1970a, b, c) which are discussed in Section 1.1.4.2.

Davies and Jones (1975) repeated the Hockey and Hamilton study using noise at a level of 95dB and individual testing and obtained similar results. No significant difference was found in either free or ordered recall scores between noise and quiet conditions, although in both cases, scores were higher in noise. Location scores obtained in noise were significantly worse.

The results of these experiments and particularly those of Hockey and Hamilton suggest that order information is better preserved when noise conditions prevail at the time the material is presented. A further investigation of this possibility was undertaken by Hockey, Hamilton and Quinn (1972) who compared the effects of a fixed and random presentation order in a paired-associate learning situation in which subjects worked either in noise (85dBC) or quiet (55dBC). Learning appeared to be faster under the fixed condition but an interaction between noise and presentation order was also observed, with learning in noise improving strongly relative to quiet with the fixed, but not with the random presentation order. This result was interpreted as showing that more order information is stored in noise. From the results of a second experiment, it was suggested that the advantage gained from fixed-order lists in noise resulted from increased input processing. These experiments suggest that noise influences the registration of material in memory, probably by biassing attention towards particular features of the items presented for retention.

A study by Hormann and Osterkamp (1966) investigated the possibility of noise effects upon the organisation of material in memory. The authors supposed that individual differences in performance on the Stroop test would be related to the degree of clustering in free recall under noise conditions and therefore subjects were divided into two groups on the basis of low or high interference on this test. Both groups were presented with sixty words belonging to six different semantic categories (animals, trees, musical instruments, tools, containers and vegetables) in quiet and were then required to recall as many words as possible in either noise (95dB) or quiet. Three measures were taken: the number of words recalled, the number of clusters (that is, the number of times words from the same semantic category were recalled together) for the first twenty words recalled, and the time required for recall. No significant differences between the noise and quiet conditions were found on any of the three measures, although noise significantly affected the number of words recalled by high and low interference groups.

The final type of result suggests that noise may affect retrieval strategies in memory performance (Schwartz, 1974). Subjects listened to three short stories ranging in length from 375 to 525 words. Each story contained four characters, two of whose names were 'common' in terms of the frequency of occurrence in a telephone directory, while the other two were 'rare'. Three independent groups of subjects heard the stories, which had been recorded on tape, either with no added noise or with either 65dBA or 85dBA noise. Schwartz found that in the no-noise group, subjects employed a risky criterion for common names, and a cautious criterion for rare names. In noise, however, subjects employed a similar criterion for recall of both common and rare names, but sensitivity increased for common names, which was particularly marked under the high noise condition. Thus both changes in d' and β occurred in noise. Schwartz interpreted his results as supporting the hypothesis that arousal affects the accessibility of information for retrieval.

In conclusion, although comparatively few studies have been devoted to the effects of noise on memory, it appears that noise may affect the registration of material, the organisation of the to-be-remembered items in storage, and the choice of retrieval strategies.

1.1.4 Monitoring and Inspection Tasks

Monitoring or vigilance tasks are tasks, usually of long duration, in which subjects watch one or more displays in order to detect the presence of faint signals which occur infrequently at unpredictable times. The rate of presentation of signal and non-signal events, which must be discriminated from each other, is usually outside the control of the observer, i.e. the task is paced. In this section, monitoring tasks have been divided into two categories: single source, in which only one display is monitored and multisource where a watch must be kept on more than one display. Also included in the latter section are studies in which the monitoring task is subsidiary to another task, usually tracking (e.g. Hockey 1970 a, b).

The third category in this section is that of inspection tasks. Included here are tasks involving visual search and those requiring the operator to perform some cognitive operation prior to reporting the presence of a signal, rather than merely making a simple detection response. Cancellation tasks are also included here, rather than under the category of 'intellectual' tasks as is sometimes the case (Grether, 1971) since they involve the searching of a display and the reporting of the presence of a signal.

One of the main concerns of vigilance research has been the understanding of the 'vigilance decrement', the decline in the number of signals correctly detected as a function of time at work. Interest has also been shown in the effects of different environmental stresses upon the overall level of performance. The number of correct detections was the principal performance reported in the majority of the early studies of vigilance. However, more recently, with the application of signal detection theory measures to vigilance data, other indices of vigilance performance, such as the commission error or false positive rate (the number of non-signals reported as signals) have become important and results of vigilance studies tend now to be expressed in terms of the measures of d' and β referred to earlier. The use of these measures permits an assessment of the effect of environmental stresses to be made in terms of changes in sensitivity or sensory efficiency on the one hand and changes in criterion placement or 'caution' on the other. Most studies employing signal detection theory measures have indicated that the vigilance decrement is primarily due to an increase in the strictness of the response criterion adopted by observers rather than to any loss in sensitivity over time (Broadbent, 1971). Furthermore, criterion placement in vigilance situations has been shown to be significantly influenced by variations in the conditional probability of critical signals (Baddeley and Colquhoun, 1969). However, some studies have suggested that a loss of sensitivity may occur in situations where heavy demands are placed on observing behaviour, e.g. if the rate of presentation of stimulus events is high or if continuous visual fixation is required (Mackworth, 1969; Mackworth and Taylor, 1963; Parasuraman and Davies, 1977).

1.1.4.1 Single-source monitoring tasks

In general, the effects of noise on performance at single-source monitoring tasks are slight, and if a significant effect is found, then it is quite likely to be in the direction of improvement. A typical experiment showing no effect of noise was conducted by Jerison (Jerison, 1957; Jerison and Wallis, 1957). In a repeated measures design, Jerison using a 105 minute version of the 'Clock Test' developed by N.H. Mackworth, in which a subject watches a blank clock face for occasional irregularities (30 per hour) in the movement of a pointer, found that neither overall performance nor the rate of performance decline with time was affected by 112.5dB noise compared with the 'quiet' condition of 79dB.

Similar findings were also obtained by Blackwell and Belt (1971), Poulton and Edwards (1974) and Tarriere and Wisner (1962). Poulton and Edwards, however, also required their subjects to indicate their degree of confidence about the correctness of each of their responses and found that 102dBC low frequence noise produced significantly more 'certain detections' and significantly fewer 'moderately certain detections' and that 'certain' responses were made significantly more quickly than 'uncertain' ones. This latter finding agrees with that of Broadbent and Gregory (1965) who also required their subjects to register their degree of confidence in each response. In noise at 100dB, subjects tended to be more confident about the correctness of their response.

A number of studies have compared the effects of different types of noise (for example, varied and steady, or continuous and intermittent) and of different types of auditory background (for example noise and music) on performance of single-source monitoring tasks. Varying noise has been found to produce superior performance to steady noise at the relatively low intensity level of 64.5dB (Kirk and Hecht, 1963), although no significant difference was observed between the effects of periodic intermittent and continuous noise at a level of 90dB (Childs and Halcomb, 1972). However, performance tended to be better in continuous noise than in intermittent noise. Somewhat conflicting results were reported by Fornwalt (1965) in a study investigating both intensity level and type of noise. Ninety-two subjects performed a visual monitoring task for 30 minutes under continuous, intermittent or random noise at a level of 70, 84 or 92dB. The author reported no effect of intensity on performance but the number of errors increased from continuous to intermittent and from intermittent to random. While this latter finding is in the same direction as that of Childs and Halcomb, since no interaction between intensity level and type of noise is reported presumably this better performance in continuous noise was also observed at 70dB, which would appear to be in conflict with the findings of Kirk and Hecht. A possible explanation for this might be the task durations employed in the two studies (2 hours in Kirk and Hecht, 30 minutes in Fornwalt). Kirk and Hecht analysed their data for the first and second hours on the task separately and reported that the difference between the variable and constant noise only reached significance during the second hour.

The comparisons between noise and other auditory backgrounds have almost invariably been conducted using comparatively low intensity levels, so that the 'noise' condition in the context of other noise experiments is more appropriately termed 'quiet'. Such studies have generally found that music produces superior performance to noise of the same intensity (Davenport, 1972; Davies, 1972; McGrath, 1963; Tarriere and Wisner, 1962; Ware, Kowal and Baker, 1964; Wokoun, 1963) although there are some exceptions to this general finding (Poock and Wiener, 1966; Falkenback, 1970 cited by Ehlers, 1972).

To summarise, single-source monitoring tasks rarely show adverse effects of noise. Indeed, beneficial effects have been observed for certain types of noise on tasks of fairly long duration, as is generally the case for performance in music.

1.1.4.2 Multi-source monitoring tasks

Adverse effects of noise are more likely to occur on multi-source monitoring tasks, although no difference between performance in noise and quiet may be observed if the signals are easy to detect and the situation is thus less demanding. Broadbent, in England, and Jerison in the United States have both undertaken a number of studies on the effects of noise on performance at multi-source monitoring tasks and some decrement in performance attributable to noise was observed in the majority of them. The twenty dials task, which appears to have been fairly demanding, and the twenty lights task, which was somewhat easier, were the two main tasks employed by Broadbent (Broadbent, 1950, 1951, 1954). The former task consisted of twenty steam pressure gauges arranged on three sides of a square, each side being 12 feet long, with the subject situated in the middle of the fourth side, facing into the square. On the face of each six inch diameter gauge was a pointer which moved silently, and an area, marked in red, known as the 'danger zone'. Any movement of the pointer into the 'danger zone' constituted a signal which had to be corrected by the subject, who could reset the pointer using a knob placed underneath the dial. All signals remained present until detected and the measure of efficiency examined was that of time taken to detect the signals. Subjects indicated that they had detected a signal by pressing a key, after which they walked to the display to make the necessary adjustment. Fifteen signals, which were presented at intervals varying from one to 12 minutes, occurred during the 90 minutes duration of the task. Ten subjects worked at the dials task on five successive days, receiving the conditions in the order quiet (70dB), quiet, noise (100dB), noise, quiet, the first quiet session being given for practice purposes. Comparing performance on days two and five in quiet with that on days three and four in noise, there appeared to be no effects of noise on the number of signals detected. However, there were significantly fewer 'quick founds' that is the proportion of signals detected within nine seconds of their onset, in noise than in quiet.

The twenty lights test was similar to the twenty dials test, although, as noted above, it was considered apparently easier to perform. The response in this case being to press a key when a lamp was seen to come on. Performance on this task over five consecutive days with the two conditions (100dB and 70dB broadband noise) being administered in the same order as for the dials task, showed no significant effects of noise, although some impairment was apparent. In particular, performance in noise was initially superior to that in quiet but towards the end of the work period, this situation was markedly reversed. Overall, therefore, no significant difference between the two conditions was observed.

Using what also appears to have been a relatively easy task, Cohen, Hummel, Turner and Dukes-Dobos (1966) in a more recent study also failed to find an effect of either continuous or intermittent noise at 95dB upon performance at a 10-dial monitoring task. Improved performance has also been noted in one experiment (Heimstra, 1972, Exp. 4). Subjects monitored a display of thirty meters for a five second 30° deflection which occurred 120 times per hour. Subjects worked in white noise at 85dB with various on-off ratios - 0, 30, 70 or 100%. There were no differences between the conditions for the latency data but the detection data revealed significant noise effects, the mean number of signals detected being under 0% (i.e. no noise) 60.55; 30% 74.7; 70% 66.2 and 100% 62.85.

However, Jerison (Jerison, 1959; Jerison and Wing, 1957) using a multi-source version of a monitoring task known to yield a performance decrement (the Mackworth Clock Test) found that noise significantly enhanced the deterioration of performance found in quiet. Jerison compared performance under conditions of noise (114dB) and quiet (83dB). Subjects performed the three clock monitoring task, which had a signal rate of 82 per hour, under both experimental conditions with a one week interval between the sessions. No difference was observed between the mean detection rates under the two conditions but noise was found to interact significantly with time at work. Performance in quiet remained relatively stable, while in noise a marked decline occurred. In the three clock situation, Jerison suggested that the subject had to scan rapidly from display to display while searching for signals and that this demanded a high degree of flexibility of attention. In view of the results obtained by Jerison and his co-workers, it was further suggested that noise impaired this flexibility of attention and, therefore, that increasing the number of signal sources to be monitored makes it more probable that noise would impair performance. Broadbent and Gregory (1965), however, questioned this interpretation, in a study which compared performance at a single source monitoring task with performance at a three source monitoring task. The overall signal frequency, 3.43 per minute was the same in the two monitoring situations, which was not the case in the study of Jerison and Wing, where the signal frequency for the three clock task was three times as high as for the one clock task. It would appear from the results of Broadbent and Gregory that it is not necessary to use multiple signal sources in order to demonstrate adverse effects of noise, but that a high signal rate will suffice. Thus whether or not performance is impaired by noise might well be determined by the critical variable of signal frequency, although, considering the conclusions from the previous section that noise is unlikely to impair performance at single source monitoring tasks, this statement would appear to warrant further investigation. However, perhaps no effects of noise were apparent because only tasks using fairly low signal rates have been employed. Nevertheless, more recent studies, employing a dual task technique, support the view that noise affects the distribution of attention over the two tasks and is thus likely to affect performance differentially. Hockey (1970a), for example, suggests that the effects of noise are mediated by increases in selectivity, a process whereby in situations in which the perceptual load is high, task-relevant cues become progressively neglected. Complex tasks, therefore, which require the utilisation of a wide range of relevant cues, will be more likely to suffer impairment from increases in selectivity while, up to a certain point at least, the performance of simple tasks will tend to benefit.

Hockey's experimental studies certainly support this hypothesis. Hockey (1970a) required subjects to perform a combined tracking and multi-source monitoring task which lasted for 40 minutes. In the instructions given to subjects, the tracking task was designated as the 'high priority' task. A repeated measures design was used and the 'noise' and 'quiet' conditions were 100dB and 70dB respectively. Tracking performance was found to deteriorate significantly with time at work in quiet but not in noise. Signals appearing in central locations were detected more frequently in noise, while those appearing in peripheral locations were detected less frequently. Essentially the same results were obtained by Hamilton and Copeman (1970) and more recently by Poulton and Edwards (1974). In a subsequent experiment, Hockey (1970b) showed that this differential detection of signals at different spatial locations resulted from the expectation that signals were more likely to appear at central locations than at peripheral ones, and that when equal numbers of signals were seen at both locations, the differential effect of noise had disappeared. In a third experiment Hockey (1970c) found that sleep deprivation produced performance changes which could be interpreted as being the opposite of those found in noise, impairment of performance being greater on the high priority task (tracking). The change in the distribution of attention in noise thus appears to be associated with high arousal, as Easterbrook (1959) had earlier suggested in a different context.

Hockey (1973) pointed out that since inferences about selectivity changes were being made from "data relating to changes in the relative efficiency of responses to critical events . . . it is not clear whether the changes . . . do indeed occur in the selection of different sources of information, or at some later stage in the system (in response selection)". (p.136) He therefore examined this question more directly by using a three source monitoring task developed by Hamilton (1969) which required the subject to make a sampling response, for example pressing a key, in order to obtain a brief glimpse of the present state of one of the three sources. Hockey found that 100dBA noise produced increased sampling of the source on which signals had a high probability of appearing, while the opposite effect was again found with sleep deprivation. Noise also reduced the frequency with which repeat observations of a source were made before a signal was reported, while sleep deprivation increased it. 'Uncertain responses' were thus less likely to occur in noise, as was noted earlier in the section on single-source monitoring tasks. Hockey's series of studies provide considerable support for the view that the effects of noise on the performance of complex tasks are mediated by selectivity, that selectivity occurs at an early stage in the processing of task information and that, probably selectivity increases monotonically with the level of arousal.

Other studies using the dual task technique have produced broadly similar results to those described above, although the interpretation of such data has sometimes been different. Boggs and Simon (1968) investigated the effects os intermittent five second bursts of noise at 92dB during performance of a four-choice reaction-time task at one of two levels of complexity and a secondary monitoring task which was carried out simultaneously. There were no significant effects of noise on performance at the tracking task but noise produced a significantly greater increase in errors on the monitoring task when it was performed at the same time as the complex, rather than the simple, RT task. This result, which is not necessarily incompatible with the selectivity hypothesis, was interpreted in terms of the demands made by noise on the subjects' 'reserve processing capacity'. Another study (Finkleman and Glass, 1970) required subjects to perform a compensatory tracking task while simultaneously working at a delayed digit recall task. Subjects worked in intermittent noise at 80dB, which was either predictable (bursts lasting nine seconds followed by three second intervals in 'silence') or unpredictable (bursts lasting between one and nine seconds with one to three second intervals), the total duration of the noise being the same in both conditions. Performance at the primary task was unaffected by either noise condition while the unpredictable noise produced a significant deterioration in the performance of the secondary task whereas the predictable noise condition did not. Once again, the results were interpreted in terms of 'spare mental capacity'. Nevertheless, in both cases, it was the secondary task which showed the deterioration in noise, while the primary one did not.

In general, then, it seems likely that noise produces adverse effects upon performance at multi-source monitoring tasks and these effects appear to be due to a change in the way in which attention is distributed across the different components of the task. In noise, attention appears to be focused more onto the high priority components of the task and rather less on the less important aspects. Such an explanation emphasises the effect of noise on the selection of potential signal sources, an early stage of information processing.

1.1.4.3 Inspection tasks

This sub-heading covers a miscellaneous selection of tasks, some paced, but most unpaced. Many are of quite brief duration (20 minutes or less) compared with the monitoring tasks described above. Unpaced inspection tasks generally show little effect of noise (Glass and Singer, 1972), although sometimes a slight increase in speed of work is found (Davies and Davies, 1975), particularly if the task is performed in the morning (Blake, 1971). Sanders (1961) compared performance on the Bourdon Wiersma cancelling test and a cancellation version of the Kraepelin addition test under conditions of 75dB varying noise and 70dB steady noise. Little effect of noise on accuracy of performance was found, although performance tended to be more variable in the varying noise condition.

Performance of paced inspection tasks is also generally unaffected by loud steady noise (Davies and Davies, 1975). Overall performance on such tasks is also relatively unaffected by low noise levels (McCann, 1969), although McCann did report that performance was better in continuous noise than in intermittent noise when omission errors were considered. Furthermore, both the duration of the task and whether or not rest pauses are provided have been noted to exert an influence on the effects of noise on this type of task (Harris and Filson, 1971; Ehlers, 1972).

A number of experiments have focussed attention on the possible distracting effects of noise. Teichner, Arees and Reilly (1963), for example, suggested that the greater the magnitude of change in noise intensity, the greater the performance decrement due to distraction. They used a task in which ten letters of the alphabet were displayed following the release of a shutter and in which the subject controlled the exposure duration, while searching the display for one of a set of five three-letter combinations, which had been memorised beforehand. Performance throughout the 15 minute duration of the task tended to improve and no differential effect on performance (transformation into bits per second of time taken to search the 200 displays) was exerted by the five different levels of white noise - 57, 69, 81, 93 and 105dB. However, when different groups of subjects worked through the first 150 displays in 81dB noise and through the last 50 displays either at the same noise level or at one changed without warning to 57, 69, 93 or 105, the best performance on the last 50 displays was found to occur in the group for which the noise level had not changed. Performance on the last fifty slides was about the same for the groups which had changed from 81 to 69dB and from 81 to 93dB and also for the groups which had changed from 57 and to 105dB, producing a gradient of stimulus generalisation. The conclusion from this experiment was that "a change in noise level is a variable with systematic distracting effect and that the effect can be qualified in terms of the amount of change regardless of direction" (Teichner et al. p87). A partially similar result was obtained by

Shoenberger and Harris (1965) using the Tsai-Partington Numbers Test, in which subjects were required to join together dots numbered one to 25, in order, although in all noise conditions, the change in level was always to the higher level of 110dB.

Teichner and his co-workers put forward an 'arousal-distraction' hypothesis which suggested that ambient sound, either continuous or intermittent, may both facilitate and disrupt performance and which effect predominated at any time depended upon the adaption of the subject to the sound and the 'on-off' ratio (the total per cent of time the noise is on relative to the time it is off). They presumed that there would be a 'neutral' on-off ratio somewhere between continuous sound and no sound where the arousal properties of a sound and its distractive properties cancelled each other, and thus presentation of sound at this ratio, while a subject is performing a task, would have no effect on performance.

A task similar to that used by Teichner et al. has been used in a series of experiments by Warner and Heimstra (Warner, 1969; Warner and Heimstra 1971, 1972, 1973), using intermittent noise with varying on-off ratios. The task required subjects to detect a different letter from a background of homogeneous letters presented on slides. The signal probability in these experiments tended to be quite high. Results of these experiments seem to suggest that noise at 'intensities up to and including 100dB has a negligible effect on speed and accuracy on performance when the task is 'easy'. Only when the task was made 'moderately difficult' or 'difficult' by increasing the size of the letter array to be searched were significant effects of noise on performance obtained. Intermittent noise below a level of 90dB was found to have no appreciable effects on performance.

Finally, Warner and Heimstra's results indicate that intensity level determined the direction as well as the magnitude of the effect of noise on performance, a finding which also provides some support for the 'distraction' hypothesis of Teichner et al.

Two studies by Woodhead (1958, 1959) also provide some support for the view that intermittent noise can be distracting, although the impairment in efficiency is only apparent for a few seconds following a burst of noise and performance soon recovers. In both studies the task used was a version of the Mackworth multichannel test (Mackworth and Mackworth, 1956). The display consisted of ten stationary cards arranged in a row along the top of a window to form key cards to ten channels. On each card there were six symbols. At the base of the display window, more cards with symbols appeared and moved upwards until they disappeared from view, about 70 moving cards appearing in four minutes. The task was to match each moving card with the stationary one heading the respective channel by deciding how many symbols were the same on both, the correct answer lying between zero and six. The rate of work varied with the constantly changing display. All subjects worked at the task for four minutes on a noise level of 70dB, with some subjects additionally receiving four, four-second bursts of recorded noise at 100dB, at certain times. Results indicated no overall performance differences between the two groups, but there was a significant impairment of efficiency which was only apparent for a few seconds following the burst of noise, after which performance soon recovered. Woodhead (1959) found similar results using shorter bursts of noise (one second) at intensities of 85, 95, and 115dB, with bursts at 95dB and 115dB causing a significant decrement in performance during the half minute after the burst, while bursts at 85dB produced effects in the same direction but of a smaller magnitude.

Further studies by Woodhead (1964b, 1966) suggest that noise also affects the distribution of attention, although it is not entirely clear whether this effect is the same as that described in Hockey's experiment. However, since Woodhead (1964b) found that observation of the less frequent feature of a visual display was impaired in 110dB noise, apparently as the result of a shift in the subjects' priorities, it seems reasonable to regard the two effects as closely similar. Woodhead (1964b) required her subjects to search a visual display in which random numbers were presented at a rate of five per second. Some numbers were ringed and this acted as an instruction for the subject to cancel repetitions of the number until the next circle appeared whereupon he was required to change numbers. Failures to notice the circles were more common in the half a minute following the intermittent noise bursts at 110dB than following bursts at 70dB or complete quiet. It was suggested by Woodhead that the level of arousal was increased by noise and that the effects of increased arousal were to exaggerate already existing differences between the two unequally occurring features of the display, circles and numbers, such that the tendency to respond to the numbers, which were the more frequent but less important items, was strengthened, while the tendency to respond to the less frequent, but more important circles, was weakened. This apparent shift in a subject's attention in noise was similar to that produced in Hockey's experiments.

Another study which could possibly be interpreted as showing that noise affects the distribution of attention to two unequally occurring aspects of a task is that by Weinstein (1974), which showed that low-level 'intermittent' noise had no effect on the detection of the more frequently occurring spelling errors whereas it resulted in a deterioration in the detection of the less frequently occurring grammatical errors.

However, a later study (Weinstein, 1977) employing a similar proof reading task, but with approximately equal numbers of errors of each type detected by the subjects, suggested that the difference in susceptibility to noise interference of the two types of errors is not just a matter of their relative frequencies.

Fuller and Robinson (1973) also report results that demonstrate no apparent differential effects of noise upon unequally occurring aspects of a task. Their subjects performed an unpaced letter-crossing task for 24 minutes in either steady noise at five dB intervals ranging from 65dB to 90dB or in varying noise. The targets to be crossed were the letters F, H, L and X, which occurred 28, 6, 60 and 58 times respectively. There were no significant differences between the noise conditions in either the mean number of items scanned or the mean number of errors. The target letters, differing in frequency of occurrence were chosen in the hope that, if, as hypothesised by Hockey, a narrowing of attention occurred in noise, then this would have been shown by a fall in the number of the two infrequent letters (H and F) marked while performance on the other two letters (L and X) remained constant. This was not found to be the case and the authors conclude that this was possibly because subjects, many of whom remarked upon the small number of H's and F's, regarded the findings of the infrequent letters as a challenge. However, since the letters used in the experiment do not occur equally frequently in the English language, then this could have been a confounding factor in their results.

On a paced visual search task requiring two types of response, cancelling and counting, Woodhead in a further study (Woodhead, 1966) showed that noise produced a shift in favour of the activity which was preferred in quiet i.e. counting. No such shift was observed, however, when instructions emphasised cancelling, the less-preferred activity. Woodhead concluded that although noise does not always produce a change in the distribution of attention required to respond equally in two paced activities, when it does so, the preferred activity gains. Thus the shift in a subject's distribution of attention, apparent in a number of studies, appears also to be influenced by preferences.

1.1.5 Perceptual Tasks

The principal task to be considered here is the Stroop Test (Stroop, 1935) although the effect of noise upon a field-dependence test will be considered first.

Oltman (1964) examined the effects of high intensity white noise ('loud but not painful') upon performance at the Rod and Frame Test and reported a significant improvement in noise. Results were interpreted as suggesting that differences in field dependence may be due in part to differences in arousal, which in turn affect the breadth of attention (Easterbrook, 1959).

It is only recently that the Stroop Test has been used by experimental psychologists interested in perceptual selection and response conflict (Broadbent, 1971), although it has been employed extensively in studies concerned with individual differences and the effects of drugs (Jensen and Rohwer, 1966). The Stroop Test is based on the observation that it takes longer to name the colour in which a word (a different colour name) is printed than to name the colour of control stimuli, either consisting of monochromatic colour names or of non-verbal symbols, such as colour patches. The effect is known as colour-word interference, and the amount of such interference is usually assessed by subtracting the time taken to name the control colours (CN test) from that required to name the colours of colour words (CW test). In general, this latter task proves fairly difficult and the amount of interference is reduced very little, if at all, by extended practice (Jensen and Rohwer, 1966).

The test may be encountered as a possible means of measuring the ability to concentrate on a dominant, and ignore a minor task. Two studies by Houston (Houston and Jones, 1967; Houston, 1969) examined the effects of continuous variable noise at a level of about 78dB upon performance at this task and found an improvement in noise. Similar results were also obtained by O'Malley and Poplawsky (1971), who attributed their findings to an increase in arousal level in noise, which resulted in a greater ability to ignore irrelevant information, i.e. a focussing of attention in noise. The results of Houston could be similarly explained, although

Houston suggests an alternative explanation in terms of an interaction between inhibitory processes.

Unfortunately, this improvement in noise has not been equivocal. Dornic, Sarnecki, Larsson, and Suensson (1974) using 'irregular' noise at a level of between 70 and 90dB found no significant difference between this condition and one of 'no-noise'. Basow (1974) using a repeated measures design also reported no significant differences in performance at the Stroop under white noise at 100dB and a no-noise condition. Finally a study by Hartley and Adams (1974) suggested that the effect of noise on this interference depended upon the duration of the exposure. In their first experiment employing a repeated measures design, subjects were tested at the CN and CW tasks during the first ten minutes and last ten minutes of a 30 minute exposure to noise at 100dBC or quiet at 70dBC. A significant decrement in performance was observed under the noise condition at both exposure durations. However, exposure duration was confounded with practice at the task and, therefore, a second experiment, employing a noise level of 95dBC and the same quiet condition as in experiment one, was conducted. Independent groups of subjects were assigned to one of two groups: group one received a ten minute exposure to noise, group two received a 30 minute exposure to noise. Subjects performed a more 'sensitive' version of the CW interference task either immediately (group one) or after reading a magazine for 20 minutes (group two). Hartley and Adams reported a significant interaction between duration of exposure to noise and interference, the latter being less in noise than in quiet at the short exposure duration, but greater at the longer duration, and suggested a cumulative adverse effect of noise. However, this is not supported by the work of Basow outlined above in which exposure durations of more than 30 minutes were involved.

It is suggested by Broadbent (1977) that the discrepancies in results of the effects of noise on the Stroop Test may well be caused by changes in the relative salience of the colour and the shape of the print (Folkard and Greeman, 1974). In conclusion, the effects of noise on the perceptual tasks included here appear to be inconsistent. However, where short exposures to noise do produce significant effects these tend to be in the direction of improvement.

1.1.6 Psychomotor Tasks

Early studies of the effects of noise on psychomotor performance tended to show that such performance was not impaired by noise (Pollack and Bartlett, 1932; Laird, 1933). Stevens (1941) demonstrated that continuous aircraft noise at 115dB compared with that at a level of 90dB did not affect performance on either a 3-D compensatory tracking task or on a pursuit rotor task. Similarly, another World War II study at Tuft's College (1942 - cited by Plutchik) also reported no effects of a two minute burst of noise upon azimuth tracking. Probably the most frequently employed psychomotor task, at least as far as the effects of noise are concerned, is tracking, and more recent studies have also failed to obtain significant effects of noise on various types of tracking tasks (Brewer, Ammons and Ammons, 1951; Plutchik, 1961; Hack, Robinson and Lathrop, 1965). Hack et al., however, in a partial replication of Plutchik's study, did obtain an initial decrement due to intermittent noise followed by a gradual improvement in performance.

Other types of psychomotor tasks have also been shown to remain unaffected by noise. A two-hand coordination task was shown by Miles (1953) in the Benox study to be unaffected by jet-engine noise at 125-135dB and performance on mirror-tracing tasks was unaffected by either intermittent (105-122dB) noise (Plutchik, 1961) or continuous (110dB) noise (Cohen, Hummel, Turner and Dukes-Dobos, 1966). Similarly no significant effects of continuous or intermittent noise (115dB) were observed on a rowing task which was considered to involve a large amount of body musculature (Loeb, 1957).

It would seem from the foregoing studies that noise exerts no significant effects upon psychomoter performance. However, a number of exceptions to this have been noted. Weinstein and McKenzie (1966), for example, found that performance at the Minnesota Rate of Manipulation Test was significantly better in 100dB white noise than in a control condition. The task required subjects to turn over as many blocks as possible using both hands in a series of five second trials. Facilitative effects of noise upon another simple psychomoter task were also obtained by McBain (1961). Noise, consisting of speech played in reverse and varying considerably in loudness, resulted in improved performance as measured by error rate on a copying task in which subjects were required to hand print continuously, and in sequence, seven pairs of capital letters. However, the awareness of having made an error was unaffected by noise. McBain assumed that the variable noise improved performance by raising arousal level in a monotonous work situation. Similarly, the improved performance in noise reported by Weinstein and McKenzie was also interpreted in terms of arousal. Two studies employing tracking tasks (rotary pursuit) have also reported facilitatory effects of noise (Catalano and Whalen, 1967; Heimstra, 1972).

Unfortunately there are also some studies which suggest detrimental effects of noise and there appears to be no obvious difference between the two sets of studies which might account for the discrepant results obtained. Grimaldi (1958) in a study of tracking ability observed a tendency for more errors, less precision and far longer response times to occur at noise levels of 90 and 100dB, particularly in the frequency range of 2400-4800Hz. However, it is unclear which, if any, of these differences reach significance, since the table giving the overall differences in performance between noise and quiet (Table 1 p.38) does not agree with the text. Simpson, Cox and Rothschild (1974) using a pursuit rotor task lasting for fifteen minutes and a noise level of only 80dB, found that performance was significantly impaired by continuous noise transmitted through head-phones. Finally, Eschenbrenner (1971), employing a complex psychomotor task involving manual image motion compensation investigated the effects of two kinds of intermittent noise (periodic and aperiodic) as well as continuous noise at three different intensities, 50, 70 and 90dB. Eschenbrenner found a marked decline in performance as a function both of noise type and of noise intensity. All noise types impaired performance, compared with the control condition, with the continuous noise condition producing the least, and the aperiodic noise condition the most, impairment. Performance also declined as intensity level increased. The task used by Eschenbrenner clearly differs from the other tasks described in that it is much more complex, and impairments of performance attributable to noise might therefore be expected to occur.

However it is difficult to account for the results to Simpson et al. and to a lesser extent those of Grimaldi.

Finally, Harris in a number of studies (Harris, 1968) examined the effects of very high intensity noise (120-140dB) on the performance of discrimination and psychomoter tasks. At these intensities impairments were usually obtained, particularly when the noise exposure was asymmetrical, one ear being protected by an ear-protector. Harris discusses his results as demonstrating a possible effect of high intensity noise on the vestibular system. However, such an effect is rather different from the other effects discussed above.

In general, the results investigating the effects of noise on psychomotor tasks demonstrate that very simple tasks may show an improvement in noise, moderately difficult tasks remain unaffected, while very complex tasks are liable to impairment, although some exceptions to this generalization have been outlined above.

1.1.7 Reaction Time Tasks

Reaction time (RT) studies fall into two main categories: (1) discrete RT studies where the RT task is not a continuous one, there being a short pause between presentation of each RT stimulus; (2) serial RT studies, where the task is continuous. These tasks may be further subdivided into simple RT tasks where there is only one stimulus, and choice RT tasks where a subject has to respond correctly to one of a number of possible stimuli. Although very few experiments have been carried out on the effects of noise on discrete RT, a number of studies have investigated noise effects on serial RT.

Fairly representative of the early studies of noise upon reaction time is that of Cassel and Dallenbach (1918). In general, their results suggested that the effects of noise (sound hammer striking an anvil and amplified noise) upon simple RT are inconsistent. Two later studies, however, suggest that noise tends to lengthen RT (Pascal, 1953; Theologus, Wheaton and Fleishman, 1974). Pascal reported that a noise level of 116dB significantly increased the RT of mental defectives from 530 milliseconds to 750 milliseconds. Similar results were obtained in the study by Theologus et al. using 'normal' subjects and intermittent (random and patterned) white noise at 85dB. Subjects were required to keep the index finger of their non-preferred hand on a back-lighted push button and to press the button as rapidly as possible whenever the light behind the button came on. Three measures of performance were obtained on this task: (1) mean RT, which was the mean of all RT's less than a 'response block' (this was a longer than normal response, a lapse-in-performance measure similar to the phenomenon referred to in Bills, 1937 as response blocking); (2) the number of 'response blocks'; (3) the mean duration of the 'response blocks'. Results indicated that performance was degraded following exposure to random intermittent noise. However, this degradation was highly specific. Initial exposure to noise slowed down the speed at which subjects normally responded, but did not increase the number of, or duration of, response blocks.

A study conducted early in World War II (Stevens, 1941) also noted a lengthening of RT in noise (115dB) compared with quiet (90dB) in a serial RT task in which subjects manipulated an aeroplane stick and rudder bar to divert a beam of light at a target. However, it has since been suggested (Stevens, 1972) that subjects performing in quiet were able to make use of auditory cues, which were unavailable to subjects working in noise, since at the higher level the noise masked these sounds. Under the same noise conditions Stevens found no impairment of performance at a serial disjunctive RT task in which subjects had to press a key with the appropriate hand or foot depending on which of four lights was illuminated. More recently Lawton (1972) using a self-paced task requiring a combination of basic reaction function with a simple coding and STM function noted a significant impairment in mean response time under noise (commonly heard noises such as cannon-firing, helicopter flyover, jet-aircraft flyover, etc.).

A large number of experiments conducted on serial choice reaction time have employed the five-choice serial reaction task developed at the Applied Psychology Unit in Cambridge (Leonard, 1959). In this task five neon lights and five corresponding brass discs are displayed to the subject in the form of an equilateral pentagon. The subject has to tap the disc corresponding to the lamp which is on, using a brass-tipped stylus. Tapping any disc turns off the lamp which is on, and turns on one of the four remaining lamps, following a random sequence. The lighting of a bulb is contingent upon a disc, not necessarily the correct one, being tapped. Three measures of performance are possible, the number of correct responses, the number of errors, and the number of long response times (1500 milliseconds or longer). The task duration is usually 30 minutes. The important characteristics of this task are that it is continuous, being performed without a break and that it is self-paced.

The studies using this task, described below, were all conducted at the Applied Psychology Unit and have the advantage, which is rare in noise research, of enabling the performance of similar groups of subjects, in this case naval ratings, working at the same task, under similar experimental conditions, to be compared. Probably, therefore, more information is available concerning the effects of noise on performance at the five-choice serial reaction task than is available for any other task. The principal results of studies using this task are summarised in Table I. It can be seen from this table that significant results are most frequently obtained with errors. Most studies report a significant increase in the error rate, although in five studies no effect on errors was obtained and in one, in which 'green' noise was employed, the error rate was significantly reduced in noise. Only one study reports any change in correct responses in noise and only three a significant increase in gaps. Although the results of these studies are not in complete agreement, they show a degree of consistency and it seems that error rates, and, sometimes gaps are likely to be adversely affected by noise. Speed of work, assessed in terms of the numbers of correct responses, is seldom influenced by noise however.

Table 1 Summary of the results of experiments comparing the effects of noise on performance at the five-choice serial reaction task

Experiment	Duration of Task	Noise Levels: Noise	Noise Levels: Quiet	Performance Measure: Corrects	Performance Measure: Gaps	Performance Measure: Errors
Broadbent (1953)	30 min.	100dBA	70dBA	o	o	+
Broadbent (1957b)[a] Experiment 1						
High frequency noise	25 min.	100dB	90dB &	o	o	+
Low frequency noise			80dB	o	o	o
Colquhoun & Edwards (1975)	30 min.	100dBA	70dBA	+	b	o
Corcoran (1962)	30 min.	90dB	c	o	o	o
Hartley (1973)[d]	40 min.	100dBA	70dBA	o	+	+
Hartley (1974)[e] Experiment 1	40 min.	95dBC	70dBC	o	o	+
Experiment 2[f]				o	+	o
Hartley & Carpenter (1974)[g]	40 min.	95dBC	70dBC	o	+	+
Poulton & Edwards (1974)	30 min.	102dBC[h]	80dBC	o[i]	o	-
Wilkinson (1963) Experiment 1	30 min.	100dB	j	o	o	+
Experiment 2				o	o	o

o, + and - refer respectively to no change, a reliable increase or a reliable decrease with noise when noise and quiet conditions are compared. In all experiments except those of Hartley (1973, 1974) who used housewives and professional men, naval ratings acted as subjects. Hartley and Carpenter (1974) used two housewives and fourteen naval enlisted men. All studies apart from Broadbent (1957) used a repeated measures design. All experiments except that of Poulton and Edwards, who used 'green' noise, used white noise.

(a) Three noise levels were compared: 100, 90, and 80dB. Independent groups were used to compare the effects of noise level, but each subject performed the task both in high and low frequency noise.

(b) No analysis of the data on gaps due to the failure of the recording equipment.

(c) Noise was presented via head-phones. These were also worn in the quiet condition but the noise level is not specified.

(d) Two groups of eighteen subjects were used, one group receiving knowledge of results (KR) while the other did not. Since KR had no reliable effect on performance, performance scores of the two groups were pooled for further analysis.

(e) This experiment also compared the effects of intermittent and continuous noise. The results in Table I refer only to the comparison between continuous noise and quiet.

(f) This experiment compared noise and quiet conditions with and without ear protection. The results in Table I refer only to the comparison between noise and quiet without ear protection.

(g) This experiment compared the effects of free field and head-phone noise. The results in Table I refer to the comparison between free field noise and quiet conditions.

(h) This experiment employed 'green' noise.

(i) The number of correct responses was reliably increased in noise during the first five minutes of the task.

(j) The quiet conditions in these experiments are described as:- "a slight residual speaker noise and faint room noises which occasionally filtered through the walls of the cubicle". (p.333)

1.1.8 Time Estimation Tasks

Very few studies fall into this category and those which do are of two main kinds, one in which the time judgement is incidental to some other task performed by the subject and the other in which the time judgement is carried out in the absence of any other task. The method of time estimation in these two kinds of studies also varies. In the former, the method employed is that of production whereas in the latter it is one of reproduction (Bindra and Waksberg, 1956). The time intervals to be judged have also been of varying lengths, ranging from ten minute intervals to those of a few seconds.

The effect of noise on the ability to estimate relatively long time intervals was examined by Jerison and Smith (1955). During the performance of a complex counting task, which was extremely attention-demanding, subjects were required to press a telegraph key, independently of the counting, at what they judged to be successive ten minute intervals. In each of two experimental sessions, subjects worked in noise at a level of 77.5dB for the first 30 minutes, after which the noise level was increased to 111.5dB, for half of the subjects for the remaining 90 minutes of the task, while for the other half it was maintained at the control level. Results from the final 90 minutes only indicated that under 'quiet' conditions (77.5dB) subjects responded every 8.79 minutes on average, whereas under noise conditions (111.5dB) they responded every 7.16 minutes, this difference being significant at the 2% level. The difference between the groups in the first half-hour was not significant. The quiet group showed no significant change in time judgements over the four thirty-minute periods of the task, whereas the noise group did, there being a significant reduction in estimates in every half-hour period. The greatest drop occurred from the first period to the second, that is when moving from quiet to noise conditions.

Loeb (1956), in an experiment primarily designed to check Jerison's findings, examined the effects of noise (110dB) and relative quiet (80dB) on the estimation of ten minute intervals while subjects completed jig-saw puzzles. The mean number of seconds judged equal to ten minutes (600 seconds) was 606.2 in noise and 542.6 in quiet, a difference which just failed to reach significance at the 0.05 level. These results are similar to those of Jerison and Smith for the quiet condition (542.6 seconds for Loeb, and 527 seconds for Jerison and Smith) but markedly different for the noise condition (606.2 seconds and 430 seconds) suggesting that the effects of noise act in opposite directions in the two experiments. The tasks used in the two studies probably differed considerably in the demands they placed upon attention, with the task used by Jerison and Smith being the more attention-demanding. In their task the subject did not control his own rate of work and the subjects' STM appears to have been quite heavily loaded. In addition, the task used by Jerison and Smith was twice as long.

Other experiments have either been concerned with the effects of varying noise programmes on immediate reproductions of the duration of a briefly presented stimulus (Hirsh, Bilger and Deatherage, 1956), or have employed a rather different kind of experimental situation, in which subjects have been asked to estimate when a moving target, which suddenly disappeared behind a mask, would arrive at a fixed point, a cross-hair (Jerison and Arginteaunu, 1958; Jerison, Crannell and Pownall, 1957). However, these studies have not produced clear-cut results. Nevertheless, Jerison and Arginteaunu proposed a 'two-factor' approach to the effects of noise on time estimation. As an acoustic stimulus, it expands the subjective time scale and as a source of stress it contracts the time scale. Results of specific experiments depend, therefore, on the aspect of the noise that plays the more important role in the particular situation. "This implies that the intensity of the noise will be an important variable in such experiments, and comparison among moderate noise levels (as were involved in the Hirsh et al. experiment) will emphasise effects of noise as acoustic stimulation. Comparisons in which very loud noises are involved will superimpose a stress effect which acts in a direction opposite to the noise effect." (Jerison and Arginteaunu p.18). If other factors of the experimental situation, e.g. task demands also affect the aspect of noise that plays a predominant role in a particular situation, then Jerison and Arginteaunu's proposal could account for the differing results of Jerison and Smith (1955) and Loeb (1957). However, the two-factor approach was suggested in part by work employing the rate projection situation which, although related to the more typical time judgement experimental situation, cannot be considered identical to it and, therefore, caution is required when considering the interpretation of noise effects on time estimation measured by more conventional methods.

The effects of noise upon time judgements have not received much attention since the 1950's but it would seem from the above studies that noise may exert some influence upon the estimation of time, but the direction of this cannot be specified with certainty.

CHAPTER 2

NOISE AND MEMORY

In this chapter some theoretical questions concerning the effects of noise are considered followed by a more detailed examination of the effects of noise upon memory

Form the previous chapter it is clear that, in some task situations, noise can exert effects upon performance. The experimental data are not completely consistent however, and there have been a number of studies which have failed to find effects of noise on efficiency and not all of these can be criticised on methodological grounds. Thus noise can undoubtedly exert beneficial or adverse effects upon task performance but it does not invariably do so.

One of the principal determinants of these effects upon efficiency is likely to be the nature of the task. Adverse effects of noise are more likely to occur if the task is paced or if it contains a large perceptual component, requiring the integration of information from several sources.

If an impairment of performance does occur then a study by Hartley (1973) suggests that its magnitude is a function of the duration of the noise exposure. His subjects performed the five-choice serial reaction task, in the last half of, or throughout, a 40 minute session. Noise at an intensity of 100dB was presented during the first 20 minutes only, the last 20 minutes only, or the whole session. Hartley found that 20 minutes of noise exposure or 20 minutes of prior task performance produced approximately equal impairments of performance in the second

20 minutes of the session, and that 40 minutes of noise exposure produced twice as much impairment as 20 minutes. However, whether the task was performed for 20 minutes or 40 minutes did not affect the amount of impairment produced by noise. The effects of prior performance and noise did not interact; their effects were independent and additive. Quite apart from the effects of time at work, Hartley concluded that noise exerted an influence on performance which is that of "a slowly accumulating stress, the effects of which take a similar time to dissipate" (p.260) and that during exposure to noise, arousal level gradually increases. Thus changes, either detrimental or beneficial, in performance found at the end of the task result from an increase in arousal level and the size of such performance changes is dependent on the duration of the noise exposure.

The inverted-U relationship between arousal level and efficiency has become a useful explanatory concept in the fields of stress and personality and from it has developed the arousal theory of stress (Broadbent, 1971). Support for this theory has tended to come from studies concerned with the effects of combinations of stresses, since in practical situations, environmental stresses rarely occur singly and therefore various combinations have been investigated along with a number of other 'host factors' such as sleep deprivation, fatigue, or drugs which may be present with the external stresses and may influence the way in which performance is affected by the external stresses.

Indeed the effects of noise have been studied in conjunction with a number of other stresses (Grether, 1970) including sleep deprivation (Corcoran, 1962; Wilkinson, 1963; Hartley and Shirley, 1977), alcohol (Hamilton and Copeman, 1970; Colquhoun and Edwards, 1975), heat (Grether, Harris, Mohr, Nixon, Ohlbaum, Sommer, Thaler and Veghte, 1971; Grether, Harris, Ohlbaum, Sampson and Guignard, 1972; Poulton and Edwards, 1974; Viteles and Smith, 1946; Wilkinson, 1969), vibration (Harris and Shoenberger, 1970; Harris and Sommer, 1971, 1973; Sommer and Harris, 1972, 1973) and knowledge of results (Wilkinson, 1961, 1963).

The effects of noise and sleep deprivation tend to be antagonistic (Corcoran, 1962; Wilkinson, 1963). Corcoran found that on the five-choice serial reaction task the increase in the number of long response times from the first half of the task to the second was significantly less marked in sleep-deprived subjects working in 90dB noise. Noise also tended to reduce the number of long response times after loss of sleep and also to increase the number of correct responses, but neither effect reached statistical significance. Noise had no effect on the number of errors made by sleep deprived subjects however. Similarly, using the same task, Wilkinson (1963) found that sleep-deprived subjects made fewer correct responses, more errors and a greater number of long response times in quiet than in 100dB noise, although only the difference in errors was significant.

Knowledge-of-results (KR) exerts a more noticeable effect on the performance of sleep-deprived subjects than does noise, however. Wilkinson (1961) found that KR considerably reduced the number of correct responses, and considerably reduced the number of errors and long response-times made by sleep-deprived subjects working on the five-choice serial reaction task. In a later experiment (Wilkinson, 1963) performance of this task was compared under four conditions using subjects who had slept normally. The conditions were (a) control, (b) KR, (c) noise and (d) KR and noise combined. Wilkinson found that KR alone produced the greatest reduction in the number of long response-times, followed by the combined condition. However, in the combined condition the number of correct responses was fewest and the number of errors greatest. It appears, then that the addition of KR or noise improves the performance of sleep-deprived subjects while that of KR and noise impairs performance of subjects who have slept normally. KR alone tends to improve the performance of individuals who have not been deprived of sleep, while noise alone either slightly impairs performance or exerts no effect. Wilkinson suggested that combinations of sleep deprivation, no KR and quiet should be minimally arousing, while those of normal sleep, KR and noise should be maximally so. He further pointed out that five-choice serial reaction performance is impaired at both of these extremes and that this harmonises with the hypothetical inverted-U model relating arousal and performance.

Performance at the same task has also been examined under the combination of noise with alcohol. (Colquhoun and Edwards, 1975). Since physiologically alcohol is considered a cortical depressant, it did not seem unreasonable to expect this stressor to act in the opposite way to noise, namely as a 'de-arouser'. Subjects worked at the task for 30 minutes in either noise (100dB) or quiet (70dB) and in addition they received a dose of alcohol at one of three levels (0, .21 mg./kg. body weight, 142 mg./kg. body weight). No significant effects of alcohol were reported on either the number of correct responses or the number of errors and there were no data available for the number of long response times due to an apparatus fault. There were significantly fewer correct responses in noise than in quiet but the number of errors in the noise and quiet groups were not markedly different because a significant interaction of the 'cross-over' type was obtained, indicating that the error rate was increased by noise in the no alcohol condition and reduced by noise in the high alcohol condition. The results were interpreted as demonstrating that alcohol at both these concentrations was acting in its known physiological function as a depressant and thus as a de-arouser which opposed the arousing effects of noise. However, the view that alcohol acts as a 'de-arouser' is not held by all investigators. The results of a study by Wilkinson and Colquhoun (1968), on the effects of a combination of alcohol with sleep deprivation or KR suggested that alcohol acted as an 'arouser'.

Hamilton and Copeman (1970) investigating the effects of alcohol and noise on the various components of the tracking and monitoring task used by Hockey (1970a), also obtained rather curious results. A beneficial, but not significant effect of noise and a significant adverse effect of alcohol, on the primary tracking task was obtained, which would be expected if noise was acting as an 'arouser' and alcohol as a 'de-arouser'. However, performance on the detection of peripheral signals was significantly worse in both noise and alcohol, suggesting they were both acting as 'arousers'. Hamilton and Copeman conclude "it is apparent that small doses of alcohol produce behaviour similar to that produced by noise - an assumed 'arouser'" (p.155). This effect embodied two factors, firstly an increase in attentional bias towards the high priority regions of the visual field and secondly a decrease in information transmission rate, which was necessary to account for the decrement in performance on the tracking task. Thus alcohol has been viewed as both an 'arouser' and a 'de-arouser' and obviously more research is required in this area.

The common mechanism relating the effects of SD, alcohol, noise and KR has been assumed to be an arousal mechanism. The effects of heat have generally been considered to be mediated by a different mechanism, but Wilkinson (1969) has suggested that moderate levels of heat might be expected to reduce the effects of noise, while higher levels might be expected to increase them. The evidence on this question is equivocal. Wilkinson's reanalysis of the data of Viteles and Smith (1946) provides some support for the hypothesis. At a temperature of 80^{o}F, performance at six out of seven tasks used by Viteles and Smith was superior in 90dB noise to that found in 80dB noise. At 87^{o}F, however, this finding was reversed, and performance in six of the tasks was worse at the higher noise level. Some support for the hypothesis also comes from the data of Dean and McGlothlen (1962). On the other hand, the data of Poulton and Edwards (1974) and that of Poulton, Edwards and Colquhoun (1975) present a somewhat more complicated picture and in these studies mild heat appears to act as an arouser in some task situations while acting differently in others. It is possible that in the first of these two studies the results may be attributed in part to the low frequency noise used.

In addition to the combinations of noise with various environmental factors, the effects of noise upon performance are generally more severe in the afternoon, when arousal level is assumed to be higher (Blake, 1971) than in the morning. Differences in the performance of extraverts and introverts under conditions of noise have also been explained in terms of arousal (Davies and Hockey, 1966).

Probably the most common explanation of continuous noise effects, particularly those of a beneficial nature, has generally been in terms of an increase in arousal level during noise resulting in improved performance, while that for detrimental effects has generally been in terms of distraction, the channelling of attention or over-arousal. However, it has been pointed out by Poulton (1977) that the tasks which suffer in continuous loud noise are those which depend upon auditory feedback or verbal short-term memory. Auditory feedback sometimes informs the subject that his response has been recorded and this can be useful information particularly when, in a psychomotor task for example, there is a confusing directional relationship between control and display, where the control buttons are difficult to locate or when considerable control pressure is required. Sometimes auditory feedback helps to augment inadequate visual feedback. Similarly, Poulton suggests that verbal short-term memory can help a subject to keep track of what he is doing in tasks involving words, letters or numerals. Noise can mask this auditory feedback or inner speech. Indeed, in a very persuasive article Poulton (1977) reviews the studies showing deleterious effects of noise and suggests that in all cases, the obtained effects of noise could have been due to the masking of auditory feedback or inner speech. The tasks concerned in this review have generally been of the psychomotor-type, but obviously more research is needed before one can say with certainty that masking is the sole cause of deleterious noise effects. However, Poulton's interpretation of deleterious noise effects in terms of either masking of task relevance noise or the masking of rehearsal loops has been criticised in some detail by Broadbent (1976). However, one such study noted by Poulton is that of Simpson, Cox and Rothschild (1974) in which a reduced time on target was observed in noise (this study is discussed in more detail later) and this is considered by Poulton to be due to masking. Nevertheless, this impairment in performance could be prevented by preloading the subject with glucose and it is not clear why a preloading with glucose should prevent a deterioration in performance in noise, if deleterious effects of noise are due solely to masking as suggested by Poulton.

At the present time, it would seem that the arousal theory of stress is the most often quoted explanation of continuous noise effects and the theory would appear to cope reasonably well with most of the data, although the question of whether or not deleterious noise effects are the result of over-arousal or masking obviously needs further investigation.

Despite Broadbent's cautionary note that his definition of arousal is based purely on a behavioural level nevertheless various physiological indices have been considered to reflect an individual's position on this continuum and a number of reviews have summarised the evidence of these physiological changes during exposure to noise. (Davies, 1968; Welch and Welch, 1970). If arousal level is held to be gradually increased during exposure to noise, and if physiological measures provide an index of the level of arousal, then changes in physiological measures during noise exposures can provide evidence as to whether arousal levels increase or not. Such an investigation into an individual's physiological response to loud noise during the performance of a fairly demanding task was undertaken by Helper (1957). Measures of skin conductance heart rate and forehead muscle tension were recorded while subjects worked for 60 minutes on a complex counting task, in which three lamps flashed at different rates. When any one lamp had flashed four times, the subject was required to press the lever corresponding to the lamp and begin a fresh count. Performance was assessed in terms of the number of correct responses. Following practice with the task, subjects were exposed to three experimental conditions. In the first two conditions, the task was performed in continuous broadband noise at a level of 110dB and in quiet. In the third condition the subject experienced the noise without performing the task. In all three conditions, a significant increase in skin conductance with time on task was obtained and both heart rate and muscle tension remained at around the same level. Thus physiological adaptation to the continuous noise did not occur in Helper's experiment and this study is frequently taken as evidence for the view that noise increases arousal level, and in the case of skin conductance at least, supports the hypothesis that arousal level increases with the duration of exposure to noise. However some differences in the overall level of autonomic reactivity across the three experimental groups are evident. The average level of skin conductance was significantly higher in the combined noise and task condition than in either the noise-alone or task-alone condition, but there was no difference in average level between the two latter conditions. Heart rate and muscle tension were significantly higher in the two task conditions than in the noise alone condition. However, no difference in either measure was observed between the two task conditions. Thus the effects of physiological activity produced by noise and those produced by task performance tend to summate. Helper suggested that loud noise may subtly increase the cost of mental work, since the combination of the noise and task conditions produced generally higher levels of physiological activity without significantly affecting output. Similar results were obtained by Conrad (1973) who observed that continued good performance in noise is accompanied by a somewhat increased intensity of effort in the form of a significant increase in finger blood volume pulse response.

In contrast to Helper's study is one by Glass and Singer (1972), using intermittent noise, which provides evidence of physiological adaptation to noise. They investigated the effects of presenting bursts of broad band noise, consisting of conversations in different languages and various types of machinery noise superimposed on each other, on autonomic reactivity during task performance. Subjects worked at tests of cognitive performance involving relatively high mental processes such as number comparison, addition and a proof-reading task requiring the detection of the letter "A", for just under twenty minutes. The noise, at levels of 108dBA ('loud') or 56dBA ('quiet'), was presented in one of two basic schedules - 'fixed intermittent' in which nine-second noise bursts were presented at fixed intervals during the test session, so that the noise onset was predictable, and 'random intermittent' in which the same number of noise bursts were presented on a random schedule, so that noise onset was unpredictable. A control condition of no-noise was also employed. Skin conductance, finger vasoconstriction and muscle action potentials from the neck and forearm were the physiological measures which were recorded. In summarising their work, Glass and Singer reported that physiological adaptation invariably occurred, regardless of the noise intensity or the presentation schedule used, or whether the subject believed he had control over the termination of the noise through a 'panic button' placed on the response panel. Manipulation of the noise presentation appeared to have no substantial effect of physiological adaptation - it always occurred. They did report one exception, however, and this occurred in a study in which the interstimulus intervals were long, averaging 90 seconds, compared with a condition in which they were short, averaging 51 seconds. The physiological measure taken on this occasion was skin conductance and adaptation did not occur with the long stimulus intervals, whether the noise presentation schedule was fixed or random. This result is in agreement with earlier studies, using stimuli other than noise (for example, mild electric shock) which suggested that interstimulus interval is an important determinant of the rate at which physiological adaptation occurs. However, apart from the one exception already noted, the results of Glass and Singer demonstrating physiological adaptation imply a gradual reduction in arousal level. Nevertheless, even though the individual becomes adapted to the noise, the authors suggest that working in noise also exerts a psychological cost, which reveals itself in tasks performed subsequent to the noise exposure and they provide numerous examples of the behavioural after-effects of noise, such as diminished frustration tolerance and impaired efficiency. Whether the magnitude of the physiological response during noise exposure is an indication of this cost needs further investigation, but it seems that physiological and psychological adaptation are only loosely related and represent different ways of accommodating to noise.

A recent study by Simpson, Cox and Rothschild also supports the view that noise is stressful. They found that a subject's performance at a 15 minute pursuit rotor task was significantly impaired in 80dBA white noise but this impairment could be prevented by preloading the subject with 18 milligrams of glucose in 100 millilitres of water. However, the same preloading of glucose impaired performance in Q(50dBA). In noise the blood glucose level fell significantly, while in Q it did not, and Simpson and his colleagues suggest that blood glucose levels may be a useful indication of stress.

It would thus appear that a number of researchers have tried to relate noise effects to changes in physiological arousal despite Broadbent's cautionary words: "We can then say that the general state which is being affected by sleeplessness and noise is one of arousal, but we must be clear that in the present state of knowledge we are defining it as such on the basis purely of behaviour and not of physiology. The physiological concept of arousal is certainly of interest and of ultimate relevance to the one we have found from behaviour, but at this stage the connection of any suggested physiological measure and the psychological state is too remote to make it practical to attach one concept directly to the other." (Broadbent, 1971, p.413).

Initially the concept had been introduced as a behaviourally-inferred construct (Duffy, 1957; Schlosberg, 1954) and various peripheral measures such as heart-rate and GSR were identified as indices of arousal level. Arousal has also been defined directly as central nervous system activity (Lindsley, 1951; Hebb, 1955). Problems with the use of these physiological definitions of arousal have since arisen. Dissociation of EEG activation and behavioural manifestations of arousal can occur (Feldman and Waller, 1962). It has also been found that peripheral measures of arousal such as heart rate, palmar conductance, and muscle-action potentials are not highly correlated (Lacey, 1967; Taylor and Epstein, 1967). Therefore, variables which can be shown to alter any one of these definitions of arousal may not necessarily be expected to have the same effect on another measure of arousal. Lacey (1967) has suggested that the concept of arousal needs drastic revision and has presented a forceful case for separating electrocortical arousal, autonomic arousal and behavioural arousal, each of which may be different and complex forms of arousal in themselves.

The relationship between changes in arousal level and performance on various tasks has received considerable attention and results of studies have generally shown an inverted-U relationship between level of arousal and performance. Short-term memory tasks, however, appear to be an exception (Blake, 1967; Baddeley, Haller, Scott and Snashall, 1970); and an upsurge of interest in the effects of arousal on verbal learning and memory has resulted in three recent reviews on the area (Uehling, 1972; Craik and Blankstein, 1975; Eysenck, 1976). Thus, while doubts about the unitary nature of arousal and its behavioural consequences must induce caution in the interpretation of noise effects in terms of arousal, nevertheless the majority of studies of the effects of noise on memory tasks (see Table 2) have been interpreted in terms of arousal theory following a number of studies which have suggested that short-term memory is impaired under conditions of high arousal, while long-term memory is

Table 2 Summary table of the experiments examining the effects of noise on memory tasks

Author	Independent Groups	Repeated Measures	Noise Level	Quiet Level	Continuous Noise	Intermittent Noise	N at Presentation	N at Retention Interval	N at recall	Auditory Presentation	Visual presentation	Meaningless Material	Meaningful Material	List Length	One Presentation only	More Than One Presentation	Recognition	Recall	Immediate	Length of Delay	Beneficial Effect of N	Detrimental Effect of N	No Effect of N
Miller (1952) (cited in Corso)		✓	111dB		✓				✓	✓	✓		✓	15 & 10		✓		✓		30min			✓
Kobrick (1952) (cited in Corso)		✓	115dB		✓		✓ ✓ o o		✓ o ✓ o		✓	✓		10		✓	✓	✓		20min			✓
Hormann & Todt (1960)	✓		75phons; 55 "	no noise; "	✓		✓				✓	✓		8				✓				✓	✓
Berlyne, Borsa, Craw, Gelman & Mandell (1965) Exp. 2	✓		72dB; 58dB	"; "	✓		✓		✓		✓	*a		18		✓		✓				✓	✓
Exp. 3		✓	35dB; 75dB	"; "	✓		✓		✓		✓		✓	18		✓		✓		24hr		✓	✓

Table 2 cont.

Berlyne, Borsa, Hamacker & Koenig (1966) Exp. 1	√	75dB	no noise	b √	{√√ √○ ○√ ○○}	√	√	40	√	√	24hr	{√√ √√}
Exp. 2	√	75dB	"	√	{√√ √○ ○√ ○○}	√	√	40	√	√	√	{√√√√}
Uehling & Sprinkle (1968)	√	80dB	"	√	√	√	√	10	√	√	{2min 24hr 1wk}	√√ √
Sloboda & Smith (1968)	√	72dB	"	√	√	√	√	7	√	√	{2sec 12sec}	√ √
Sloboda (1969)	√	72dB	"	√	√	√	√	7	√	√	{2sec 12sec}	√ √
McLean (1969)*c Exp. 1	√	85dB	"	√	√	√	√	6	√	√	{2min 24hr}	√ √
Exp. 2	√	85dB	"	√	√	√	√	6	√	√	{2min 24hr}	√ √
Archer & Margolin (1970)*d	√	100dB	"	√	*e√	√	√	16	√	√	5sec	*f√
Hockey & Hamilton (1970)*g	√	80dB	55dB	√	√	√	√	8	√	√	√	*h
O'Malley & Poplawsky (1971)	√	75dB 85dB 100dB	no noise	√	√	√	√	6/24	√	√		*i

Table 2 cont.

Hamilton, Hockey & Quinn (1972) Exp. 1	√		85dBC	55dBC	√	√	√	√	10	√	√	√	*j	
Wesner (1972)*k		√	65dB	no noise		√	√	√	20	√	√	√	√	
Baumeister & Kistler (1975)*l														
Exp. 1	√		80dB		√	√	√	√	8	√	*m	{2min / 1wk}	1wk: √	2min: √
Exp. 2	√		80dB		√	√	√	√	6	√	√	{2min / 1wk}		2min: √; 1wk: √
Davies & Jones (1975)	√		95dBA	55dBA	√	√	√	√	8	√	√	√		*n

a) Stimulus terms were meaningless patterns, but response terms were male first names.

b) Paired-associate learning task, with noise present during the stimulus presentation and stimulus + response presentation but not during intervals between stimuli.

c) Experiment 1 was concerned with incidental learning, whereas Experiment 2 involved intentional learning.

d) Subjects were told to remember some items but not others.

e) Noise occurred either just before stimulus presentation or immediately afterwards.

f) Beneficial effects of noise only for remember items.

g) Group testing of subjects employed.

h) Noise exerted no effects on free recall, a beneficial effect on ordered recall (p+0.055) but a significant detrimental effect on an incidental locations task.

i) No effects of noise on the number of trials required to learn six central words to a criterion, but fewer peripheral words were recalled in 85, and 100dB than in no noise or 75dB.

j) Beneficial effect of noise only for fixed order of presentation.

k) Subjects were kindergarten children.

l) Subjects were second- and fifth-grade children and the stimuli employed were pictures of objects.

m) Two types of task were employed - serial and free learning.

n) No effect of noise on either ordered or free recall but a significant detrimental effect of noise on an incidental locations task.

facilitated. These studies are of two main types; in the first type, type A, arousal level has been manipulated through the learning material itself, while in the second type, type B, arousal has been manipulated independently of the stimulus material. In type A studies arousal level has usually been evaluated by the subjects' galvanic skin response which is monitored during the presentation of the material to be learned. High arousal items are less likely to be recalled than low arousal items after a short delay of only a few minutes, but better recalled after longer delays (Kleinsmith and Kaplan, 1963, 1964; Walker and Tarte, 1963; Corteen, 1969; Lavach, 1973). This appears to be the case not only for discretely presented stimuli but also for continuously presented material (Levonian, 1966, 1967) whether it presented auditorilly or visually (Levonian, 1968a). In type B studies, various techniques of manipulating arousal level have been utilised including the administration of drugs (Batten, 1967), the observation of subjects (Geen, 1973), individual differences (Howarth and Eysenck, 1968; Osborne, 1972) and delayed auditory feedback (King and Wolf, 1965), and these have generally yielded similar results. The manipulation of arousal level by the provision of incentives has also been investigated (Weiner, 1966a, b; Weiner and Walker, 1966) and similar results have been obtained although this work raises problems of interpretation since the incentives became informational, unlike the other ways of manipulating arousal which have been used.

In both type A and type B studies, statistically significant arousal effects have generally been obtained suggesting an interaction between level of arousal and delay. These results have usually been interpreted in terms of the theory of perseverative consolidation. The theory proposes that the occurrence of any psychological event results in a perseverative trace process which gradually establishes permanent memory at the expense of immediate memory (a process which serves to protect the consolidating trace from interference) and that an increase in arousal during the associative event will produce a more intense trace activity, thus rendering the association less available for immediate memory, while consolidating it for greater permanent memory (Walker and Tarte, 1963). In addition to these studies employing temporary shifts of arousal, similar results have been obtained from those involving more long-term shifts. Physiological arousal is known to increase gradually during the day (Kleitman, 1963) and performance at most tasks shows a corresponding improvement (Blake, 1967). However, an 'inverse rhythm' was found with a STM task and recent attempts to replicate this finding have found performance to be superior in the morning although a tendency was also noted for performance on a LTM task to be superior in the afternoon (Hockey, Davies and Gray, 1972; Folkard, Monk, Bradbury and Rosenthal, 1977). In reviewing the work on memory performance and time of day (TOD), Hockey and Colquhoun (1972) suggested that performance on tasks involving the immediate processing of information increases over the day while performance on STM tasks decreases. This suggestion was extended by Folkard (1975) who found performance on two tasks of logical reasoning that involved both STM and immediate processing to show a compromise between the functions relating STM and immediate processing to TOD. Further, Folkard, Knauth, Monk and Rutenfranz (1976) systematically varied the STM component of a visual search task in an experimental shift work situation. With a low STM component performance rose over the day, and was highly correlated with body temperature. With an intermediate STM load, performance showed no correlation with temperature while with a high STM load, performance was negatively correlated with temperature.

Similarly, if sleep-deprived (SD) subjects are considered to be in a state of low-arousal, then the results of Hamilton, Wilkinson and Edwards (1972) showing better performance on the running digit span test after SD appear to be consistent with those of the TOD studies. Because loud noise is assumed to raise arousal (Davies, 1968; Hockey, 1969) then attempts to explain the effects of noise on memory have generally been in terms of arousal and consolidation. (Berlyne et al., 1965; McLean, 1969). However, a closer inspection of Table 2 reveals a number of studies which do not appear to support the usual finding of impaired STM performance under conditions of high arousal (e.g. Archer and Margolin, 1970). Apparently inconsistent results have also been noted in studies using other techniques of manipulating arousal. The 'inverse rhythm' for STM tasks in TOD studies has not always been observed (Patrick, Davies and Cumberbatch, 1974; Jones, 1974 cited in Patrick et al.; Jones, 1975) although it has been pointed out by Patrick et al. that shifts in basal level of arousal may be qualitatively different from the temporary induced shifts of Type A and Type B studies since work using EEG alpha abundance as an index of arousal failed to show any significant change over 0700, 1100, 1800 and 2000 hours (Gate, Harpham and Lucas, 1972). Similarly anomalous results have been obtained from studies on sleep deprivation and memory (Edwards, 1941; Gieseking, Williams and Lubin, 1957; Williams, Lubin, and Goodnow, 1959; Williams, Gieseking and Lubin, 1966), although once again problems of interpretation have arisen due to the lack of agreement on whether SD subjects are under or over-aroused (Malmo and Surwillo, 1960; Corcoran, 1964) although it would appear that task demands exert an influence on this (Wilkinson, 1965). Thus noise studies are not alone in yielding results inconsistent with those of the Michigan group and indeed other techniques of producing temporary arousal shifts have similarly yielded apparently inconsistent results (Maltzman, Kantor and Langdon, 1966; Corteen, 1969). Consequently some modification of the consolidation approach seemed inevitable. Berlyne (1967) developed further the idea that an intermediate level of arousal is optimal and that verbal responses will be most effectively reinforced when arousal is at an intermediate level. He also distinguished between learning and performance. He considered short-term recall to be influenced both by the influence of arousal on performance and arousal on learning while long-term retention is influenced only by arousal on learning. He also suggested that differences for arousal effects on short- and long-term retention are due to differences in the particular inverted-U shape functions which relate arousal to performance and to learning. Levonian (1972) proposed a retentivity-accessibility hypothesis, which distinguished between the retentivity (storage strength) and accessibility (retrieval strength) associated with an item. He suggested that arousal was differently related to storage strength and to retrieval strength. However, Levonian evaluated his hypothesis with respect to only a small sample of the relevant literature and the main evidence for his hypothesis derives from the reanalyses of these studies.

Since both hypotheses failed to take into account task difficulty, they were considered inadequate by M.W. Eysenck, who, therefore, proposed that the optimum level of arousal (conjointly determined by item and subject arousal) which is required for successful performance on a retention test is directly related to the accessibility or functional dominance of the appropriate response. He suggested that high arousal has the effect of biassing the subject's search process toward readily accessible stored information more than is the case with lower levels of arousal, and he considers that although most studies have confounded storage and retrieval, nevertheless, substantive evidence for his generalisations have been obtained in his own work (Eysenck, 1974b; 1975a; 1975b).

One point which emerges from all the three recent reviews is that far more research is needed before a better understanding of the effects of arousal on memory is obtained. Similarly they do seem to agree that there is good support for a positive relation between arousal at learning and long-term recall and that the results for short-term recall are confused, differing for different experimental designs. Results using white noise as an arouser agree with the finding that arousal at learning facilitates long-term recall (Berlyne, Borsa, Craw, Gelman and Mandell, 1965; Berlyne and Carey, 1968; McLean, 1969). The precise effects of noise during learning on short-term recall are, however, as yet unclear. There is no clear-cut relation apparent between noise intensity and the result and there is some suggestion in the data that different experimental paradigms may produce different results. However, there is evidence to refute Broadbent (1971) that noise only affects performance when it reaches an intensity over 90dB.

There is also evidence that noise affects learning qualitatively by increasing reliance upon order information and some evidence that other stresses may have similar effects. As noted in Chapter one section 1.1.3 Hockey and Hamilton (1970) found that, while the noise level did not affect the number of items recalled when correct position was not taken into account, the percentage of items recalled in the correct position was higher under 80dB noise (p=0.055). It was also noted that Hamilton, Hockey and Quinn (1972) found that 85dB noise produced better performance in their paired-associate learning task than 55dB noise when the order of the pairs remained constant from trial to trial. They explained their results by reference to evidence obtained by Hockey (1970a, b, c) that when arousal is high, attention is narrowed to sources given high priority, following an earlier suggestion by Easterbrook (1959) that the range of cues utilised is reduced under high arousal. Easterbrook, however, assumed a narrowing of the visual field rather than a deployment of attention. Hockey and Hamilton (1970) suggest that with high arousal, subjects take in less information but attend to it more and Hamilton, Hockey and Quinn (1972) further suggest that the extra processing capacity allocated to the main task is used to preserve order information. However, it is implied that the extra capacity may be used to process any relevant cue and is not allocated specifically to order information. Thus Easterbrook suggested that less information is processed when arousal increases, while Hockey and Hamilton suggest that the same amount is processed but what is processed changes, but in neither case is an explanation offered of how increased arousal narrows attention.

Dornic (1973) has suggested that noise acts like other methods of increasing task difficulty. He found that several such methods had little effect on the retention of lists of items in the correct order, but reduced the probability of recall when order was not retained. He argues that increased difficulty induces regression to a more primitive 'parrotting' back form of learning. He does not state whether such a strategy can also be induced by instructions to learn order. The lists in his experiments consisted of a mixture of letters and digits and increase in difficulty also tended to reduce grouping by category in recall. Dornic's suggestion is reminiscent of the ideas of Craik and Lockhart (1972) about depth of processing. Also, Schwartz (1975) has suggested that increased arousal facilitates recall based on physical rather than semantic properties of stimuli.

A rather different explanation of continuous noise effects upon verbal short-term memory has been proposed by Poulton (1977), who suggested that noise can mask rehearsal in verbal short-term memory just as it masks the perception of speech. He considers this explanation is able to account for the results of a number of experiments examining the effects of continuous noise upon verbal short-term memory tasks, which he reviews and which demonstrated adverse effects of noise. However, he attributes the improvements in noise on other tasks (e.g. vigilance, reaction time) to an increase in behavioural arousal (Poulton, 1978), and further points out that the increase in behavioural arousal tends to cancel out the detrimental effect of masking of auditory feedback or verbal short-term memory (Poulton, 1977) and that these two opposing effects together are in principle sufficient to account for all the reliable effects of continuous noise upon performance, both improvements and deteriorations. He suggests that these two opposing effects are demonstrated in an experiment by Hamilton, Hockey and Ryman (cited by Poulton, 1977) in which continuous noise at 78dB increased the rate of work in a letter transformation task when it involved a minimal STM load, the result reflecting an increase in the level of behavioural arousal. However, when the STM load was considerable the rate of work was reduced in noise presumably reflecting the masking of verbal short-term memory by the noise.

Whether or not continuous noise masks verbal short-term memory and rehearsal, a closer inspection of the tasks reviewed by Poulton and upon which he presumably bases his proposals reveals an unusual choice of tasks, e.g. Jerison's complex counting task (Jerison, 1959), searching for two-digit numbers in a 6 x 15 matrix of pairs of two-digit numbers (Harris, 1972), and sorting cards by ink colour (Hartley and Adams, 1974). However, there is no direct evidence from studies employing typical short-term memory tasks for a masking interpretation.

Tulving (1972) distinguishes two types of memory, memory for an item and memory that an item occurred in a particular situation and he refers to these as semantic and episodic memory respectively. The latter has been studied extensively by psychologists and the procedure adopted tends to follow a general pattern: presentation of materials to be remembered; retention interval; test. The presentation is usually carried out sequentially at a specified rate, ranging from about four items per second to one item every ten seconds, depending on the experimenters interests, although simultaneous presentation of the items has occasionally been used. Sequential presentation, however, has the advantage of allowing the experimenter control over the order in which the subject encounters the items and also the time he has between items, although this does not necessarily ensure that he spends an equal time attending to them. Retention intervals in 'STM' experiments range from fractions of a second to a number of minutes and these may or may not be filled with an interpolating task, designed to prevent rehearsal. A further difference between experimental procedures is the type of retention test adopted. These fall into two broad categories - recall, and recognition, but there are many variations of these basic procedures. For example, subjects may have to recall the items in a list serially, i.e. recall the list in order starting at the beginning ('ordered' recall) or they may be free to recall the words in any order ('free' recall). Murdock (1974) distinguishes an intermediate type of recall which he calls 'constrained' recall in which subjects have to record the items in a list in their correct box, but may do so in any order: i.e. subjects may start by writing down the last three items in the last boxes first. Other differences in procedure occur in the scoring of the subject's responses, particularly for ordered recall. It is thus apparent that many different experimental paradigms, many of which have not been mentioned here, have been employed in the study of short-term memory and a closer inspection of Table 2 reveals the diversity of experimental procedures adopted in the noise and memory studies. Not only are there differences between the various components of the memory task, e.g. the length of the list employed, single and multiple learning trails, length of the 'immediate' retention interval, the type of recall required (recall versus recognition) and the degree of meaningfulness of the material used, but also there are differences in the noise presentation (e.g. intensity, type of noise, etc.) and when it occurs. Indeed the apparent inconsistency between the results is rather reminiscent of the controversy in the 1950's and 1960's about short-term memory and how it is affected by variables such as presentation rate, retention interval and so on. Probably not until the rise of interest in the possibility of two components of the serial position curve, which permitted a more fine-grained analysis of recall data, were some of these anomalies resolved. By varying one factor at a time (e.g. list length, presentation rate ec.) possible differential effects on the two parts of the serial position curve could be observed and certainly many factors were found which did exert such differential effects. Similarly it is difficult to compare all the studies of the effects of noise on memory tasks because of the lack of common elements. It seemed desirable to undertake a study in which the noise and control conditions remain constant, while the various parameters of memory tasks, such as list length, presentation rate and retention interval are examined in turn. This thesis is thus an empirical study of the effects of noise upon short-term memory performance undertaken in an attempt to provide further understanding of the apparently inconsistent results already obtained.

CHAPTER 3

NOISE AND ATTENTION ALLOCATION IN SHORT-TERM MEMORY AS A FUNCTION OF LIST LENGTH

As mentioned previously numerous studies have been reported in the literature which suggest the task specificity of noise-produced changes in human performance. A salient parameter of the tasks investigated which determines whether an effect will be observed and its direction is the degree of difficulty of the task. Research findings generally support the conclusion that the likelihood of obtaining a demonstrable noise effect is increased as task demands become more difficult (Boggs and Simon, 1968; Broadbent, 1954). Results of these studies suggest that generalisations based on tests of various noise conditions at a single level of task difficulty may not be valid for increased or decreased levels of difficulty.

Recent work concerned with task performance under conditions of high arousal has emphasised the changes that appear to occur in the allocation of attention to different components of the task. For example, it has been shown by Hockey (1970a, b) that loud noise, which may be considered to raise arousal level (Broadbent, 1971; Davies, 1968), biases attention towards high-priority task components and away from low-priority ones. The possible changes in attention allocation to relevant and irrelevant task components in a short-term memory situation were examined by Hockey and Hamilton (1970). Subjects who worked in N or Q, were required to recall in correct order a list of eight words which were projected one at a time on to a screen. The irrelevant cue was that the words were presented in different corners of the screen, but subjects were not informed of this. After subjects had recalled the words, they were reminded that the words had been presented in different locations and were asked to indicate the appropriate location for each word. Hockey and Hamilton found that the ordered recall scores of the group working in N were better, but not significantly so, than those of the group working in Q, while their recall of locations was significantly worse. The finding was interpreted as showing increased selectivity in noise, attention being allocated to the high priority task component (locations) to a greater extent in the N group.

Since it was observed in the previous studies cited that N effects are related to the level of task difficulty, it may be that the effects of noise obtained in the Hockey and Hamilton study are not generalisable to tasks of varying difficulty, especially since the list length used in their study was eight words, which is usually considered to be within the normal memory span. An examination of the effects of noise on short-term memory tasks varying in difficulty was therefore considered appropriate. This variation in difficulty was achieved by increasing the amount of information to be remembered that was presented to the subject i.e. increasing list length. The relationship between list length and task difficulty is suggested by the results of Postman and Phillips (1965) and Johnston, Greenberg, Fisher and Martin (1970). The first study observed that percentage recalled (free recall) decreased with increasing list length and the second found that performance on a tracking (subsidiary) task deteriorated as a function of increasing list length on a memory task, implying that more processing capacity is required for memory tasks involving longer list lengths.

Davies and Jones (1975) point out that it may be inferred from Easterbrook's (1959) hypothesis that the relation between arousal level and selectivity is linear up to a certain point, depending on task demands and thereafter selectivity ceases to operate, since all task irrelevant cues are already being ignored. The most probable consequence of this being a marked deterioration in the performance of the irrelevant task and a possible deterioration of the relevant task under conditions of high arousal, compared with conditions in which the level of arousal is somewhat lower.

The present experiment was therefore designed to examine the effects of noise and task difficulty upon selectivity. It uses the same task as that employed by Hockey and Hamilton and has two main aims

(i) to replicate their findings with respect to noise.

(ii) to investigate the generalisability of their results to the same task at varying levels of difficulty.

Since Kahneman, Peavler and Onuska (1968) suggest that task difficulty is a determinant of arousal, with increasing task difficulty resulting in increased arousal, then if selectivity increases with increasing arousal, it is hypothesised that the effects of noise will result in greater selectivity on the most difficult task.

3.1 Method

3.1.1 Subjects

Ninety-six undergraduates, 48 males and 48 females aged between 18 and 25 years, participated in the experiment and were paid for their services. Sixteen subjects, 8 males and 8 females, were randomly assigned to each of the six groups. Noise List Length 8 (NL8), Noise List Length 12 (NL12), Noise List Length 16 (NL16), Quiet List Length 8 (QL8), Quiet List Length 12 (QL12), Quiet List Length 16 (QL16). The subjects were tested individually.

3.1.2 Apparatus

A list of sixteen common monosyllabic words drawn from the A or AA frequencies of the Thorndike-Lorge word count (Thorndike Lorge, 1944) was compiled and 64 36 x 24cm. slides were made each containing one of these words printed in block capital letters 3mm. high in one of its four corners, such that each word appeared once in each of the four corners. The words were: BLESS, CHEEK, CRIED, FLAME, GRAND, HEART, HENCE, MARCH, NURSE, PLACE, QUICK, SOUND, STAIR, SWING, TROOP, YIELD. Four sets of 16 slides were prepared, such that no set contained any repeated words, consecutive slides did not contain words in the same location, and each corner was used twice in the first 8 slides, once in one of the positions 9-12 and once in one of the positions 13-16. The length of the presentation list was varied and was either the first 8, 12 or all 16 of one of the four sets of slides. An additional 2 slides were left blank.

A Kodak 'carousel' projector was used to project the slides on to a plain white wall which was at a distance of 3 metres from the projector lens. The projector was connected to an electronic time interval control unit which was set to present the slides at fixed intervals.

A tape of broad-band noise within the frequency range 30-15000HZ was produced by recording the output of a white noise generator. In all experimental conditions the tape was played on a Ferrograph Series 7 tape-recorder. The loudspeaker was placed centrally on the floor in front of the wall on which the slides appeared. In the noise condition the volume control was adjusted until a Brüel and Kjaer Model 2203 sound level meter registered 90dB A at subjects head and in the quiet condition until it registered 65dB A.

3.1.3 Procedure

The subjects sat in a chair facing the wall and at a distance of 2.5 metres from it. They were instructed that upon the disappearance of the blank slide they would be shown a series of words, one at a time, when the next blank slide appeared at the end of the series, they were to write down the words on the special response sheet provided. This contained either 8, 12 or 16 boxes (depending on the experimental condition) and subjects were required to write the word in the box corresponding to its position in the list, but they were free to write down the words in any order they chose, i.e. that is, they could write down the last three words in the series in the last three boxes first. After the experimenter had ensured that the instructions had been understood, the experiment began. Each slide was presented for one second and the interval between presentations was two seconds. One of the four sets of slides was presented once only to each subject and each of the four sets was allocated to 2 males and 2 females in each of the six experimental groups. The presentation of the stimulus materials thus took 24, 36 or 48 seconds (depending on list length) and the noise was presented during this time at one of the two levels previously indicated.

During recall, however, the noise level was at the lower level for all groups. High level noise was not present during recall since previous work (see Levonian, 1972) has indicated that the effects of 'arousal' upon ST retention seem to occur only if it is present during the presentation of information.

Subjects were allowed one minute to complete their recall of the list, after which their attention was drawn to the fact that the words had been presented in different corners of the screen and they were instructed to indicate these different locations by marking an 'x' in the corresponding corner of the box for each of the words they had written down. Subjects were allowed one minute to complete their recall of locations.

Finally, in testing subjects, care was taken to control for possible TOD effects. In each experimental condition approximately equal numbers of males and females were tested between the hours of 09.00 and 11.00, 11.00 and 13.00 and those of 14.00 and 16.00.

3.2 Results

The analysis of results is divided into two main sections: the first uses the percentage measures employed by Hockey and Hamilton (1970) in order to compare their data with the results of the present experiment and the second makes a number of direct comparisons between the experimental conditions using the untransformed raw data for both words and locations.

1) Percentage measures

Three performance measures were taken and the means of these are given in Table 3 and illustrated in Figure 1. For the relevant task, recall performance was assessed in two ways: (i) by considering the % of words recalled in the correct serial position (ordered recall) and (ii) by considering the % of words correctly recalled irrespective of serial position. Performance on the irrelevant task was measured by considering the number of correct locations as a function of the total number of words correctly recalled (i.e. the free recall score). A 2 x 3 (noise-quiet; list length 8, 12, 16) analysis of variance was carried out on the arc-sin transformed percentage accuracy scores for both of the relevant task measures i.e. ordered recall and free recall. A summary table of the analysis of the ordered recall data is presented in Table 4 which shows a significant main effect of list length ($F=35.96$; df 2,90; $p < .01$). The main effect of noise approached significance ($F=2.79$; df 1,90; $p < .10$) with performance tending to be better in noise than in quiet. Comparisons between means for the main effect of list length using Tukey's method showed that a greater percentage of words was recalled from lists of length 8 than from lists of length 12 ($q=7.65$; df 3,90; $p < .01$) or length 16 ($q=11.89$; df 3,90; $p < .01$). Similarly, a greater percentage of words was recalled from lists of length 12 than from lists of length 16 ($q=4.24$; df 3,90; $p < .05$). The first-order interaction N x LL failed to reach significance.

The results of the analysis of the free recall data (Table 5) also revealed a significant main effect of list length ($F=31.89$; df 2,90;

Table 3

Table Showing Mean % of Relevant and Irrelevant Cues Recalled in Noise and Quiet

(Where appropriate, the results of Hockey and Hamilton (1970); Davies and Jones' (1975) are shown in parentheses for comparison purposes).

	Relevant Task		Irrelevant Task
	Percentage of Words Recalled in Correct Order	Percentage of Words Recalled Irrespective of Order	Percentage of Locations Recalled
List Length 8			
N	57.81 (54.12, 46.12)	78.91 (69.00, 80.00)	38.83 (32.00, 33.30)
Q	54.69 (43.75, 42.50)	75.78 (73.12, 73,75)	48.55 (48.50, 60.12)
List Length 12			
N	40.10	60.39	39.11
Q	32.26	55.72	47.75
List Length 16			
N	27.73	53.91	43.42
Q	24.61	54.68	47.60

Figure 1 Figure showing percentage accuracy and location scores as a function of list length - Experiment 1.

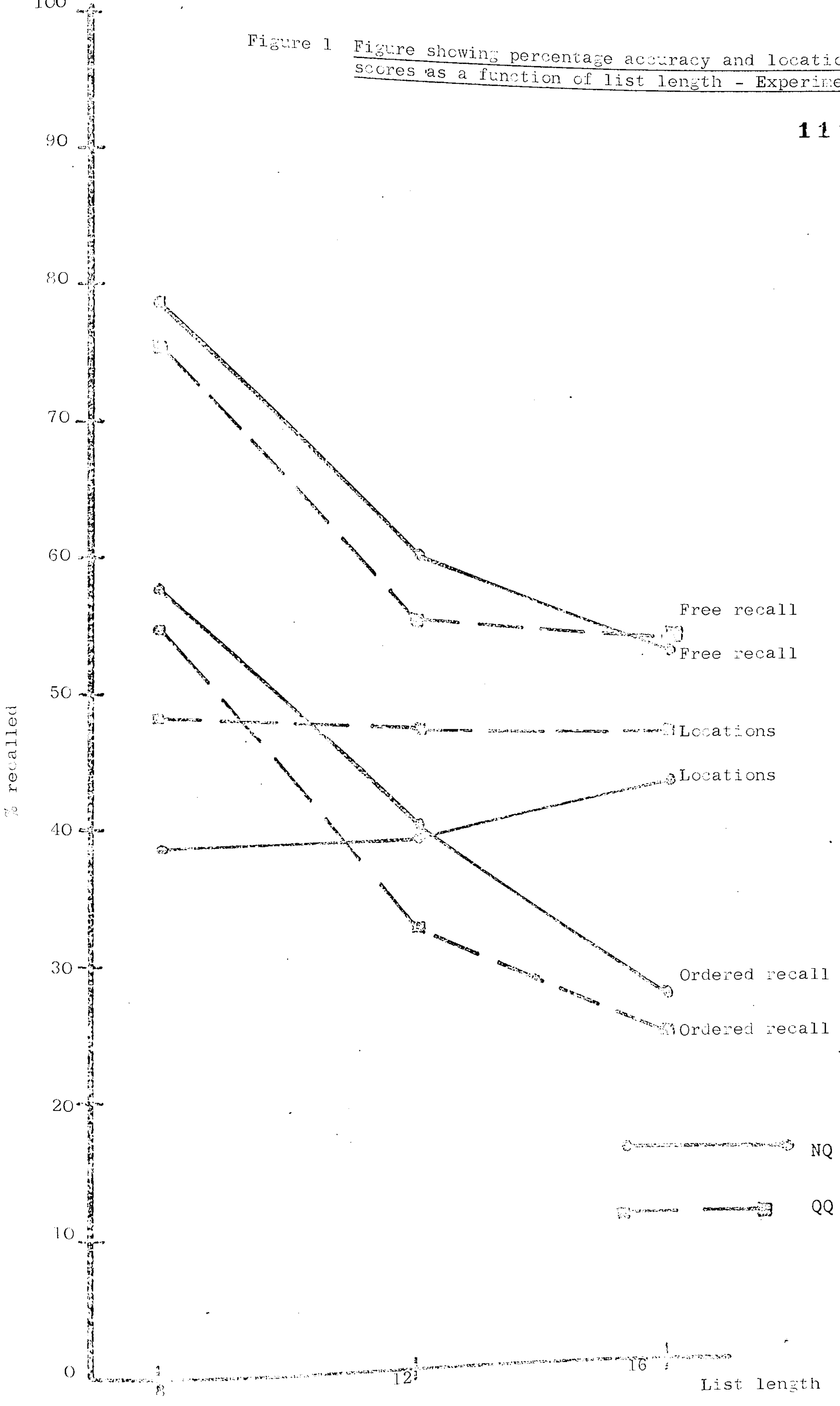


Table 4

Summary Table for Anova 1 - Noise x List Length for Arc-sin Transformed Percentage Accuracy Scores (ordered recall)

Source	SS	df	MS	F
Noise (N)	27.27	1	27.27	2.79+
List Length (LL)	703.31	2	351.65	35.96**
N x LL	5.17	2	2.58	<1
Within Cell	880.04	90	9.78	

Table 5

Summary Table for Anova 2 - Noise x List Length for Arc-sin Transformed Percentage Accuracy Scores (Free recall)

Source	SS	df	MS	F
Noise (N)	10.63	1	10.63	1.32
List Length (LL)	512.18	2	256.09	31.89**
N x LL	9.16	2	4.58	<1
Within Cell	722.70	90	8.03	

p .01) in agreement with the findings of Postman and Phillips (1965). The main effect of noise and the first-order interaction between noise and list length both failed to reach significance. Comparisons between means for the main effect of list length using Tukey's method revealed that a greater percentage of words was recalled from lists of length 8 than from lists of length 12 (q=8.96; df 3,90; p .01) or from lists of length 16 (q=10.46; df 3,90; p .01). However, the comparison between the mean percentage of words recalled from lists of length 12 and that from lists of length 16 failed to reach significance (q=1.5; df 3,90; p .05).

On the whole the findings concerning list length were similar for both ordered and free recall, a finding one would expect since list length is not one of the factors listed by Crowder (1975) as exerting a differential effect on free v. serial recall.

Performance on the irrelevant task was measured by taking the percentage of correct locations as a function of the total number of words correctly recalled (i.e. the free recall score). A 2 x 3 (noise - quiet; LL8, 12,16) analysis of variance was carried out on the arc-sin transformed percentage accuracy scores. Results of this analysis (Table 6) reveal that neither the main effect of noise nor that of list length reached significance.

Correlations between measures

Even though the subjects were not told that they were to remember in which corner each word appeared, it is possible that they may have guessed that this information would be required, and this would thus

Table 6

Anova 3 - Noise x List Length for Arc-sin Transformed Percentage Location Scores

Source	SS	df	MS	F
Noise (N)	65.64	1	65.64	2.44
List Length (LL)	5.96	2	2.98	< 1
N x LL	10.81	2	5.40	< 1
Within Cell	2,417.89	90	26.86	

become a high priority task component. If this was the case, then previous research showing increased selectivity in noise might suggest negative correlations between the percentage of correct locations and the percentage of words recalled to a greater extent in N than in Q. Spearman rank correlation coefficients were therefore computed between the percentage location score and the percentage accuracy score, for ordered recall and these are presented in Table 7. None of the correlations reached significance, although the expected tendency for the correlation to be negative to a greater extent in N than in Q was observed for all list lengths. The difference between the correlations in N and Q is significant at LL8 and LL12.

2) Raw scores

In their analysis of results, Hockey and Hamilton measured performance on the irrelevant task by considering the percentage of correct locations as a function of the total number of words correctly recalled. Referring to this measure they state, "This was necessary because the possible number of correct locations is limited by the number of words successfully reported (a subject cannot attempt to recall the location of a word he has not recalled)" (p. 867). Davies and Jones (1975) suggest that this statement is unconvincing since it seems possible for a subject to recall correctly the location of an item and yet either be unable to remember the item itself or to make an error in recalling it, and they maintained that their data included a number of instances of just such a phenomenon. In order to compare the results of the present experiment with those of Davies and Jones the statistical analyses were also carried out on the raw data for the mean

Table 7

Table Showing Spearman Rank Correlation Coefficient for Percentage Location Score x Percentage Ordered Recall Score (n=16)

	LL8	LL12	LL16
Noise	-0.393	-0.232	-0.154
Quiet	0.230	0.263	0.112

Table 8

Table Showing Mean Number of Locations Correctly Recalled, Irrespective of Whether the Corresponding Word was Correctly Recalled

	LL8	LL12	LL16
Noise	3.19	3.62	4.00
Quiet	3.69	4.06	4.50

number of locations correctly recalled, irrespective of whether the corresponding word was correctly recalled (see Table 8). The comparison between the mean number of locations recalled in N and the mean number recalled in Q, using a 2-tailed t-test failed to reach significance at each list length. Also, all comparisons between the means for each list length in N and in Q were insignificant.

So far, no mention has been made of the serial position curves obtained for the various lists in noise and quiet, and these will now be considered. Figures 2 and 3 show the mean probability of recall at each serial position in noise and quiet for ordered and free recall respectively, from which it can be seen that there appears to be a slight tendency for performance in noise to be better than that in quiet on later serial positions for lists of length 8 and 12, while the reverse seems to be the case on early serial positions. In order to examine further the possible differential effects of noise on the primacy and recency areas of the serial position curve, a 3 x 2 x 2 (list length 8, 12 or 16; serial position, first four words, last four words; noise - quiet) analysis of variance having a repeated measure on the second factor was carried out on both the ordered and free recall data. The summary table of the analysis of the ordered recall data is presented in Table 9 which shows a significant main effect of list length ($F=7.99$; df 2,90; $p < .01$) and serial position ($F=78.96$; df 1,90; $p < .01$). The main effect of noise and all interactions failed to reach significance. The mean probability of correct recall for the first and last four items in the list for the ordered recall data is illustrated in Figure 4. Comparisons between means for the main effect of list

Figure 2 Figure showing probability of recall as a function of serial position (ordered recall) - Experiment 1.

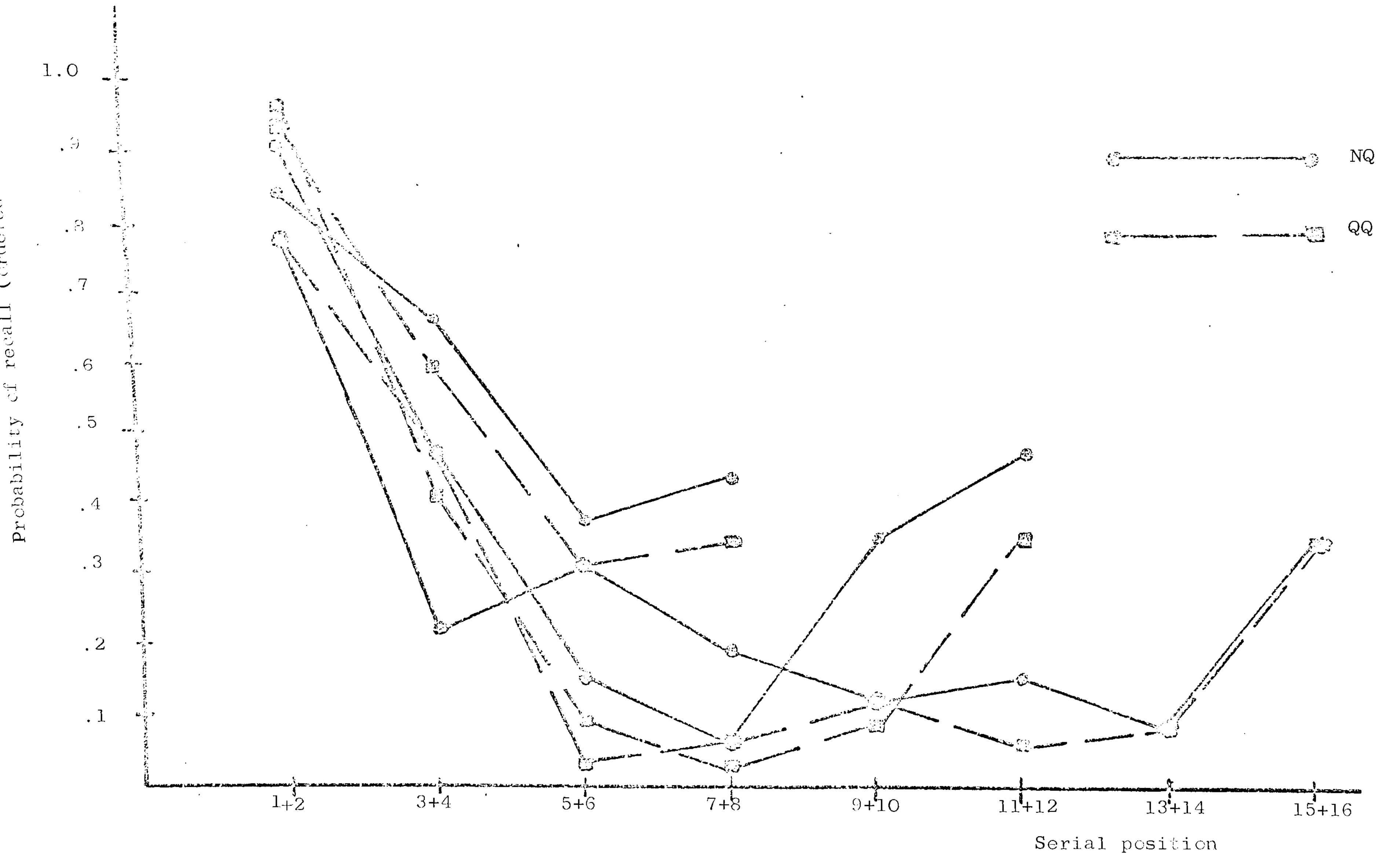


Figure 3 Figure showing probability of recall as a function of serial position (free recall) - Experiment 1.

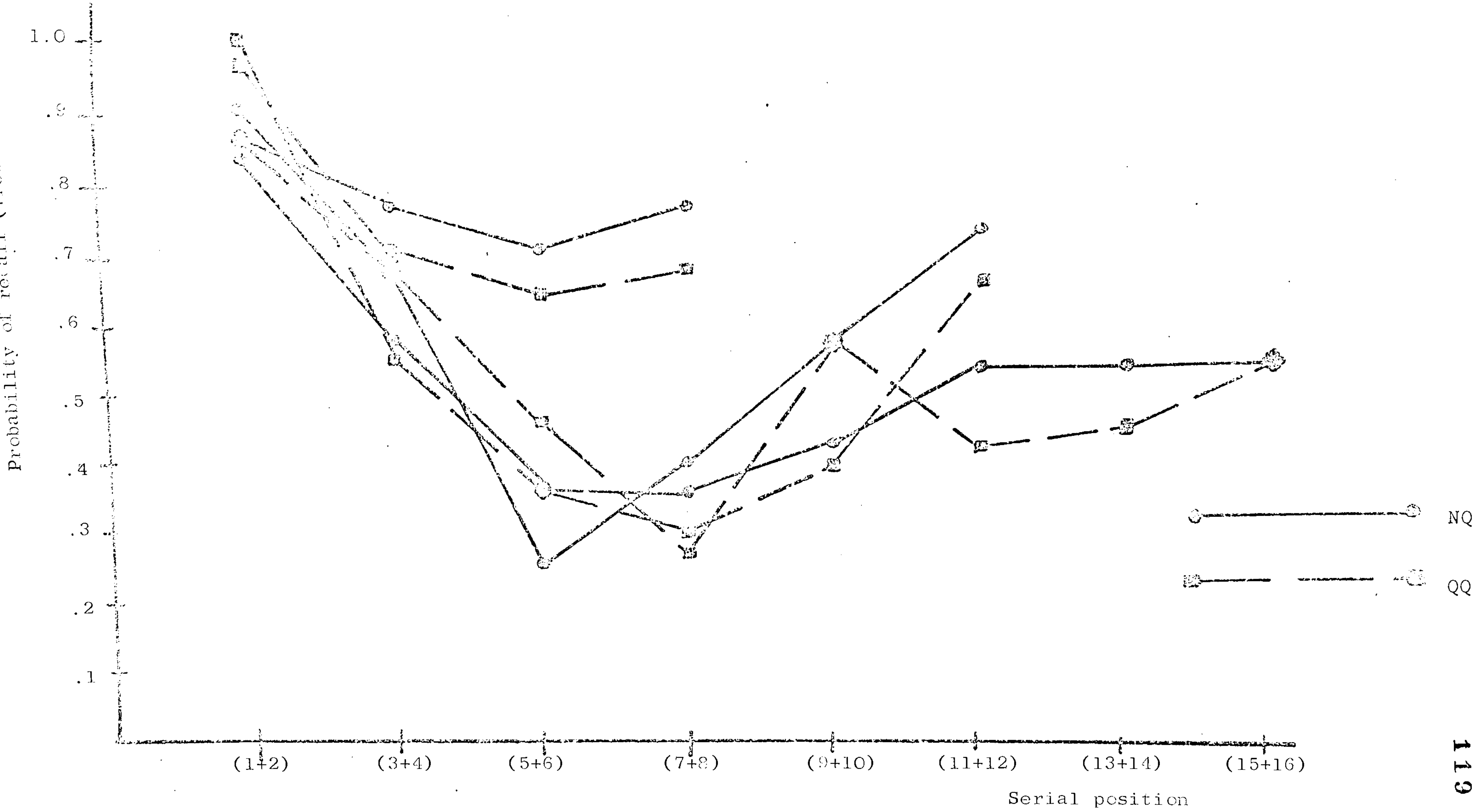
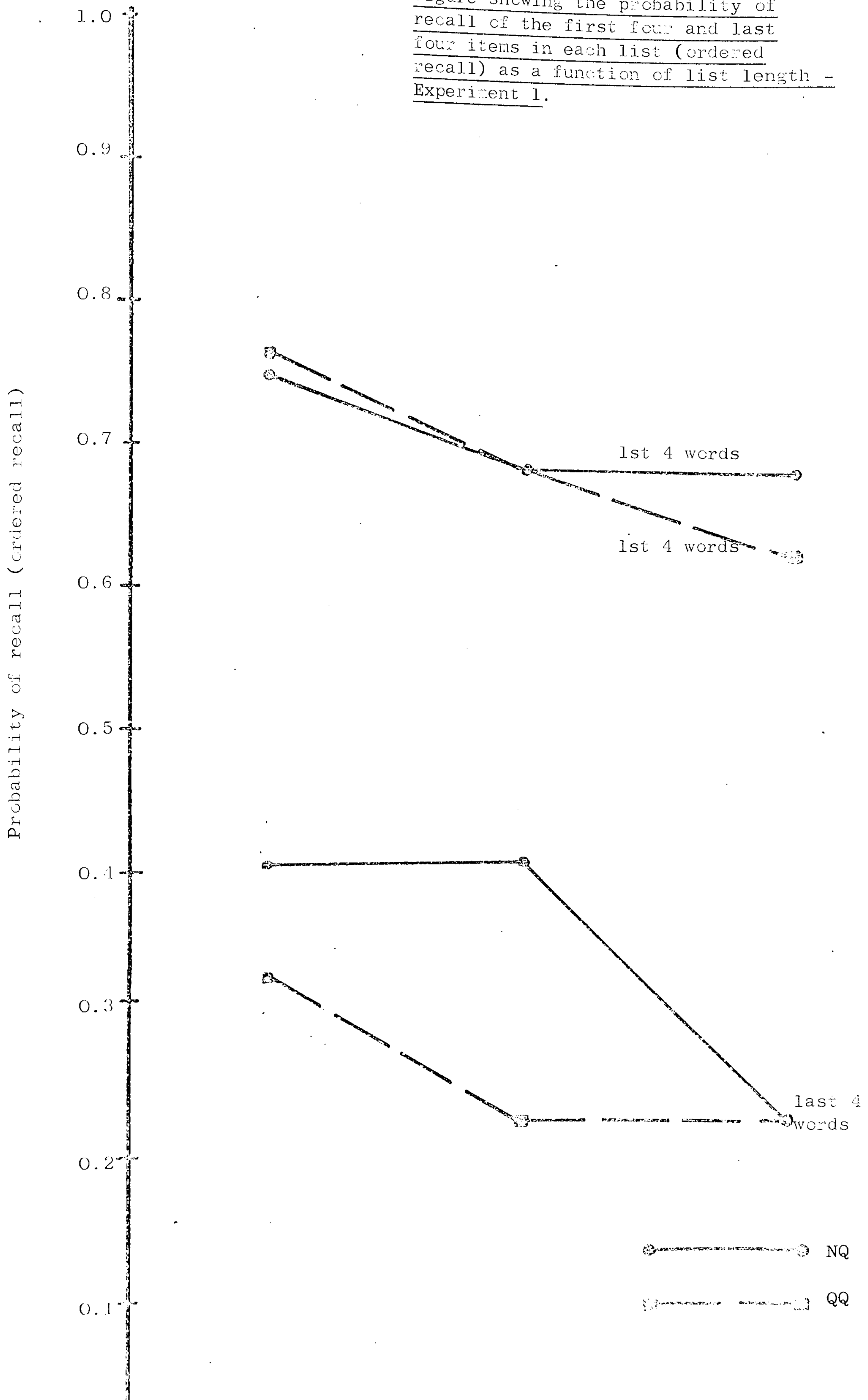


Table 9

Anova 4 - List Length x Serial Position x Noise (ordered recall)

Source	SS	df	MS	F
Between subjects	106.25			
List length (LL)	15.50	2	7.75	7.99**
Noise (N)	0.33	1	0.33	< 1
LL x N	3.17	2	1.58	1.63
Subj. w gps.	87.25	90	0.97	
Within subjects	229.00			
Serial position (SP)	105.02	1	105.02	78.96**
LL x SP	0.29	2	0.14	< 1
SP x N	3.52	1	3.52	2.65
LL x SP x N	0.29	2	0.14	< 1
SP x Subj. w gps.	119.88	90	1.33	

Figure 4 Figure showing the probability of recall of the first four and last four items in each list (ordered recall) as a function of list length - Experiment 1.



length using Tukey's method revealed that significantly fewer words were recalled from lists of length 16 than from lists of length 8 ($q=5.75$; df 3,90; $p < .01$) or length 12 ($q=3.67$; df 3,90; $p < .05$). However the difference between the lists of length 8 and 12 failed to reach significance. The Summary Table for the analysis of the free recall data is presented in Table 10. As with the ordered recall data, the main effect of serial position reached significance ($F=24.66$; df 1,90; $p < .01$) with more words recalled from the first four words in the list than from the last four words.

The main effect of list length also reached significance ($F=7.25$; df 2,90; $p < .01$). Comparisons between means using Tukey's method showed that significantly more words were recalled from lists of length 8 than from lists of length 16, but the other comparisons failed to reach significance. Neither the main effect of noise nor any of the interactions reached significance. The mean probability of correct recall for the first four and last four items in the list for the free recall data is illustrated in Figure 5.

3.3 Discussion

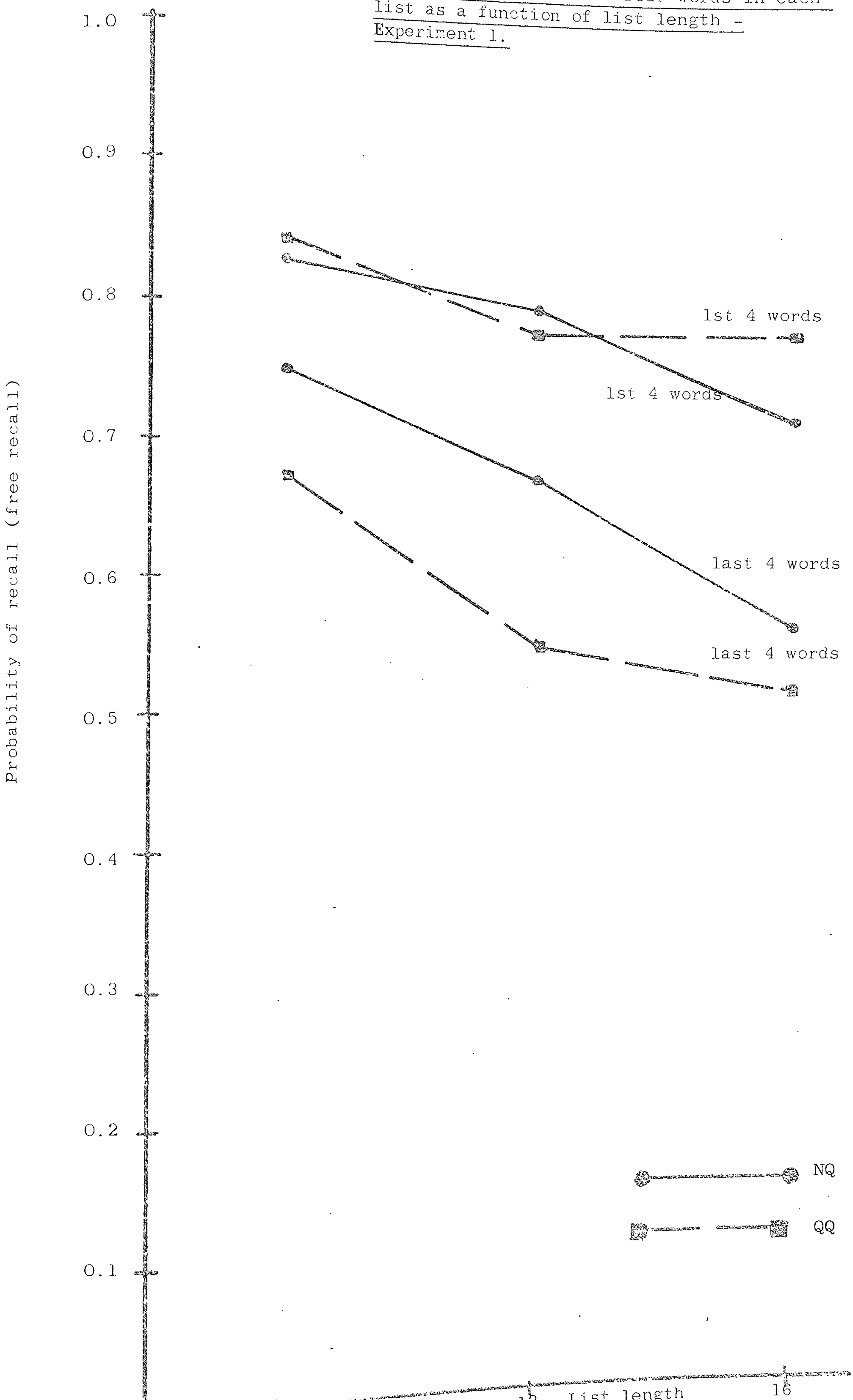
In the present experiment, increased selectivity might be demonstrated if the manipulation of the N condition caused a significant improvement in performance on ordered recall scores and a significant deterioration on the location measure. Weaker evidence for increased selectivity would be for only one of the above measures to show a significant effect, while the other showed a non-significant tendency in the opposite direction.

Table 10

Anova 5 - List Length x Serial Position x Noise (free recall)

Source	SS	df	MS	F
Between subjects	62.98			
List length (LL)	8.57	2	4.28	7.25**
Noise (N)	0.75	1	0.75	1.27
LL x N	0.78	2	0.39	<1
Subj. w gps.	52.88	90	0.59	
Within subjects	109.00			
Serial position (SP)	22.69	1	22.69	24.66**
LL x SP	0.97	2	0.48	<1
SP x N	2.08	1	2.08	2.26
LL x SP x N	0.01	2	0.00	<1
SP x Subj. w gps.	83.25	90	0.92	

Figure 5 Figure showing the probability of recall of the first four and last four words in each list as a function of list length - Experiment 1.



In terms of these criteria, the present experiment appears to have obtained only limited evidence for increased selectivity in noise. The ordered recall results revealed that the effects of N approached significance at the 5% level (a similar finding to that of Hockey and Hamilton), with performance in N being better than that in Q. As suggested above, increased selectivity in N might be demonstrated if the manipulation of the N caused a significant improvement on ordered recall and/or a significant deterioration on the location score. Since the analysis of the ordered recall data failed to reach the 5% level of significance, possible evidence for the expected increase in selectivity lay in the demonstration of an effect of N on the location scores. In the present experiment no significant differences were observed between the N and Q conditions - a result which failed to support that of Hockey and Hamilton and that of Davies and Jones (1975). However, the results of the present experiment are in the same direction as the other results cited. Since subjects may have guessed that they would be required to recall the locations of the words this may have become the 'high priority' component of the task. If this occurred then increased selectivity in N could be manifested by a larger negative correlation between ordered recall score and location score in N than in Q. As can be seen from Table 7 this appears to be the case. Although none of the actual correlation coefficients reached significance there was a significant difference between the coefficients in N and Q at list length 8 and at list length 12.

Another possible reason for the rather weak selectivity effect in N in the present experiment could be the N level employed (90dB). The N level in the other study using individual testing of subjects (Davies and Jones) was 95dB and therefore perhaps the level of 90dB was not high enough especially since Broadbent (1957a) suggest that N levels below 90dB seldom exert effects on efficiency. However, the N level in the Hockey and Hamilton study was only 80dB and yet increased selectivity was observed. However, group testing of subjects was employed and if, as Zajonc (1965) suggests, the presence of other people results in increased arousal, then the increased selectivity observed in the Hockey and Hamilton study could have been the result of increased arousal produced by not just the noise, but by the noise plus the presence of other people. However, this explanation seems unlikely since other studies have shown noise effects with N levels lower than 90dB including a study by Berlyne et al. (Berlyne, Borsa, Craw, Gelman and Mandell, 1965) which reported effects of noise at 72dB on a paired-associate learning task. Also, a 90dB N level was adopted in the pilot study and this level seemed unpleasant enough and resulted in a number of complaints from subjects.

It was hypothesised earlier that the effect of N on selectivity would be greater on the most difficult task, but this does not appear to be the case. If anything, considering the differences between the ordered recall scores in N and Q, and the percentage location scores in N and Q, selectivity appears to be less with lists of length 16 than with lists of length 12. If increasing list length does result in increased task difficulty (Johnston et al.) and increased task difficulty results in increased arousal (Kahneman et al.) then the results of this experiment indicate that the effects of N and task difficulty are not additive in their effects upon selectivity. However, the results appear to be in harmony with a suggestion put forward by Davies and Jones that the relation between arousal level and selectivity is curvilinear rather than linear. Another possibility for the lack of greater selectivity with longer list lengths is that the differences between the list lengths employed in the present experiment were not sufficient to produce any differences in arousal level.

As already noted the finding that performance on ordered recall tended to be better in N than in Q (the comparison failing to reach significance at the 5% level, but reaching significance at the 10% level) is in agreement with the two previous studies as is the lack of an effect of N on free recall ($F < 1$ in the present experiment). Taken together these results suggest that performance on STM tasks tends to be better in N than in Q when order preservation is a criterion for success. A similar finding, using a paired-associate task was reported by Hamilton, Hockey and Quinn (1972). Hamilton et al. suggest that under the influence of noise i.e. in the state of higher arousal, their subjects' better performance in ordered recall was due to an 'increase in processing power'. However, Dornic (1972) suggests that under the influence of N subjects "were obliged to use a more primitive way of coding" (p.5). Since working in N is considered to increase the processing demands made upon subjects (Boggs and Simon, 1968), then Dornic's suggestion seems reasonable in the light of work by Eagle and Ortof (1967) showing that acoustic coding occurs when subject does not have enough processing capacity available for semantic coding. If subjects working in N do rely on phonemic coding to a greater extent than subjects working in Q, then this could account for the differential effects of noise on recall performance requiring order and item information and recall performance requiring only item information. Wickelgren (1965) reported that when phonemically similar or phonomically different lists were to be recalled, ordered recall was worse for the former but item recall was either no different or better. If working in N does result in the increased utilisation of phonemic coding then this could also account for the tendency for N to differentially affect different serial positions. From Figures 2 and 3 it can be seen that performance in N tended to be better than that in Q on later serial positions while generally no better or slightly worse in the earlier part of the list.

Since recent analyses of the serial position effect in free recall have involved the division of memory into two stores, STM and LTM (Waugh and Norman, 1965; Glanzer and Cunitz, 1966) items from terminal input positions are said to be retrieved from STS, while items from earlier positions must be received from LTS. This division is supported by the observation that various experimental manipulations e.g. presentation rate, word frequency etc. affect the recall of items from early input positions while leaving the terminal ones comparatively unaffected. In contrast the effects of a delay, in which conrehearsal is prevented between presentation and recall tend to be confined to items from terminal positions. Craik and Lockhart (1972) rejected the notion of distinct storage system in favour of the view that retention reflects the 'depth' to which items are processed. Depth of processing can vary from an analysis of the physical features of an item to the formation of an elaborate code. The memory trace is seen as a by-product of the perceptual analysis; the greater the depth of the analysis, the more durable the trace. With sequential presentation of items, since the subject knows he must stop attending to the initial items in order to perceive and rehearse subsequent items he subjects these first items to 'Type II' processing, that is deeper semantic processing. Final list items can survive on phonemic coding however, which gives rise to good immediate recall, but is impaired by the necessity to process interpolated material. Thus the observed slight beneficial effect of N on late serial positions would be expected if working in N encourages phonemic or Type I coding; and since, in the present experiment, subjects are required to write down the members of the list in their respective positions but did not necessarily have to start at the beginning of the list, and they could thus have recorded the final items first.

Finally, the effects of serial position for the free-recall data in the control condition revealed that the primacy effect was very marked whereas the recency effect was much smaller and for LL8 was virtually absent. At first sight this would appear to be inconsistent with the usual SP curve for free-recall data. However, Bousfield, Whitmarsh and Esterton (1958) observed a similar tendency for a better primacy effect for list lengths of 10, 20 and 40 words. A suggestion by Murdock (1962) that this result could have been due to a stress on order in the instructions which may have given subjects a set to recall the words in the order presented, could also explain the large primacy effect in the present experiment, since although subjects could recall the words in any order, they were to be written down in the box corresponding to their position in the list and this could have encouraged subjects to attempt to recall the words in the order presented. However, Murdock (1974) notes that on the very first trial, subjects typically show more primacy and less recency than practised subjects (which would explain the results of the present experiment), but this effect is very transitory; by the second or third list subjects have shifted over. If conditions (e.g. list length) change from trial to trial, one might continue to maintain subjects at this naive level much as one gets release from PI with change of material. This could explain the findings of Bousfield et al. However, another factor operating in their experiment was that 2 minutes of an irrelevant task preceded each list and in an unpublished experiment by Donaldson, cited in Murdock, an increase in primacy as inter-trial interval is increased was noted.

3.4 Conclusion

The initial aim of the experiment was to replicate the findings of Hockey and Hamilton of increased selectivity in N was not directly achieved although weak evidence for selectivity was obtained.

There were no differential effects of noise on the recall of lists varying in length and reasons for this were considered. However, the experiment does demonstrate that N exerts more effect on ordered recall than on free recall and it was suggested that working in N results in subjects employing less deep levels of processing possibly at the expense of deeper, semantic levels of processing.

CHAPTER 4

NOISE AND THE RETENTION INTERVAL

A number of studies have investigated the effects of arousal on free-recall and some of these have already been noted in Chapter 2. In the initial study, Maltzman, Kantor and Langdom (1966) presented a list of high- and low-arousal words followed by a test for free recall either immediately after list presentation or 30 minutes later. Considerably more high- than low-arousal words were recalled at both retention intervals. A study of free-recall, briefly referred to by Kaplan and Kaplan (1968) found results agreeing with the Maltzman et al. finding of superior recall for high arousal words. Schönpflug and Beike (1964) also obtained better free-recall scores immediately after exposure to a sequence of emotional words than after exposure to a sequence of neutral words. However, not all results are consistent with those above. Farley (cited by Eysenck, 1976) found no difference between high- and low-arousal items in immediate free recall, although since recall scores were very high, it is suggested by Eysenck that a ceiling effect may have been involved. Haveman and Farley (also cited by Eysenck) studied the effects of white noise on free recall learning and found no significant difference between the WN items and control items at immediate recall. Recent work by Schwartz (cited by Eysenck) noted that the effects of high arousal on memory may be either facilitatory or detrimental. According to Eysenck, Schwartz referred to the Hamilton, Hockey and Quinn (1972) study which found that high arousal led to the storage of more information about the presentation order of the material and to a study by Hörmann and Osterkamp (1966) which found that WN led to a decrease in semantic category clustering in free recall, and came to the conclusion that "Given that arousal reduces semantic clustering but facilitates verbatim, ordered recall, it seems plausible to hypothesise that arousal facilitates recall on the actual physical properties of verbal stimuli but adversely affects memory for semantic features." In an experiment by Schwartz reported by Eysenck subjects were presented with normal sentences, anomalous strings, anagram strings and random words followed by immediate recall. The material was either presented in silence or accompanied by WN. The major finding was a significant noise-sentence type interaction in which the detrimental effect of high arousal was greatest for normal sentences, the type of material presumably containing the most semantic features. Schwartz suggested that the differential effects of arousal on memory for phonemically and semantically related material are due to processes operating at retrieval, although the paradigm he used only involved the manipulation of arousal at the time of input. However, if high arousal leads to increased selection of information about the physical characteristics of presented information and to decreased processing of semantic information (Schwartz, 1974; 1975) then taken together these could suggest that high arousal reduces the 'depth' of processing of the to-be-learned material and the results of Experiment 1 appear to be consistent with this. If the type of coding determines the durability of the memory trace, with phonemic coding of verbal material being simple and rapid and leaving an adequate primary memory trace accompanied by a relatively minor secondary memory component, whereas the semantic coding of unrelated material is relatively slow but leaves a much more durable secondary memory trace (Baddeley and Ecob, 1970) thus the beneficial effects of W on the recency portion of the serial position curve would not be expected when recall was delayed. Thus the purpose of the present experiment was to study the effects of noise on immediate and delayed recall. It was predicted that a) immediate ordered recall would be enhanced in noise and b) immediate free recall performance would show beneficial effects of noise on the later serial positions and detrimental noise effects on the early positions, while performance in the delayed condition would be worse, or at least no better, in noise on all positions.

It was decided to test each subject on a number of trials rather than just one trial for two reasons. Firstly, results from one trial only tend to be rather unstable and reflect a large amount of variance. Secondly, Keppel and Underwood (1962) showed that the characteristic short-term forgetting curve did not occur for the first sequence tested and in fact, very little forgetting occurred.

4.1 Method

4.1.1 Subjects

Eighty undergraduates, 40 males and 40 females aged between 18 and 25 years, participated in the experiment and were paid for their services 20subjects, 10 males and 10 females, were randomly assigned to each of four groups: Noise immediate recall (NI), Noise delayed recall (ND), quiet immediate recall (QI), quiet delayed recall (QD). The subjects were tested individually.

4.1.2 Apparatus

Twelve lists of 12 common 5-letter monosyllabic words drawn from the A or AA frequencies of the Thorndike-Lorge word count (Thorndike Lorge, 1944) was compiled (See Appendix 2 for complete list of words) and 144

26 x 24cm. slides were prepared each containing one of these words printed in block capital letters 3mm. high in the centre of the slide. Another 12 slides were prepared containing a 3-digit number printed in approximately the same size, in the centre of the slide. An additional 13 slides were left blank.

As in Experiment 1 a Kodak 'carousel' projector was used to project the slides on to a plain white wall which was at a distance of 3 metres from the projector lens. The projector was connected to an electronic time interval control unit which was set to present the slides at fixed intervals.

A tape of broad-band noise within the frequence range 30-15KHz was produced by recording the output of a white noise generator. In all experimental conditions the tape was played on a Ferrograph tape-recorder which was connected to a loud-speaker placed centrally on the floor in front of the wall on which the slides appeared. In the noise condition, the volume control was adjusted until a sound level meter registered 90dB A at subjects head and in the quiet condition, until it registered 65dB A.

4.1.3 Procedure

The subject sat in a chair facing the wall and at a distance of 2.5 metres from it. He was instructed that upon the disappearance of the blank slide he would be shown a series of words, one at a time. When the next blank slide appeared at the end of the series, subjects in the immediate recall condition were instructed to write down the words in the special response booklets provided, each page of which contained a row of 12 boxes. Subjects were required to put each word in the box corresponding to its position in the list, although they were free to write down the words in any order. After the presentation of the last word in the list subjects in the delayed condition were shown a slide containing a 3-digit number and were required to count backwards overtly in 3's from that number for a period of 30 seconds after which they recalled the list of words in the manner indicated above for subjects in the immediate condition.

After the experimenter had ensured that the instructions had been understood, the experiment began. Each word was presented for 1 second and the interval between presentations was 2 seconds. The presentation of the stimulus material thus took 36 seconds and the noise was presented during this time at one of the 2 levels previously indicated. Subjects were allowed 1 minute to complete their recall of the list and during this period, as in Experiment 1, the noise level was at the lower level for all groups, i.e. subjects recalled in quiet and subjects in the delayed condition also performed their interpolated task in quiet.

After the time allowed for recall, the next sequence of 12 words was started. Subjects received 12 lists of 12 words but they were not informed of the number of lists they were to receive and the response booklets contained 15 pages in order to avoid 'end-spurt' effects.

Finally, in testing subjects, care was taken to control for possible TOD effects. In each experimental condition approximately equal numbers of males and females were tested between the hours of 09.00 and 11.00, 11.00 and 13.00 and those of 14.00 and 16.00 hours.

4.2 Results

The analysis of results is divided into four sections: (i) a comparison between the results of trial 1 only (immediate recall) one with those of Experiment 1 (LL 12 only); (ii) a detailed analysis of the results of trial 1 only; (iii) a detailed analysis of the results of trials 3-12 only; (iv) a comparison between the results of sections (ii) and (iii).

(i) Comparison between Trial 1 and Experiment 1 (LL 12)

Table 11 shows the percentage correct for ordered and free (immediate) recall in the two experiments. Comparisons between corresponding scores all failed to reach significance, thus demonstrating consistency between the two experiments. The serial position curves obtained were also similar.

Table 11

% Recall scores for Trial 1 Experiment 2 and Experiment 1

	Experiment 1		Experiment 2 Trial 1 only	
	N	Q	N	Q
ordered recall	40.1	32.3	32.5	29.2
free recall	60.4	55.7	55.0	48.3

(ii) Analysis of Trial 1 only

Recall performance was assessed in two ways: (a) by considering the number of words recalled in their correct serial position and (b) by considering the number of words correctly recalled irrespective of serial position and a summary of these are shown in Table 12

A 2x3x2 (noise/quiet; serial positions 1-4; 5-8; 9-12; immediate/delay) analysis of variance with repeated measures on the second factor was carried out on both the ordered and free recall data. A summary of the results of the analysis of the ordered recall data is presented in Table 13a , which shows a significant main effect of retention interval (F=7.95; df 1,76; $p < .01$) and serial position (F=115.38; df 2,152; $p < .01$). Performance was better when recall was immediate rather than delayed. Comparisons between means for the main effect of SP using Tukey's method showed that significantly more words were recalled from the first four positions in the list than from the second

Table 12

% Correct in N and Q for Immediate and Delayed Recall (Ordered and free) for Trial 1 only

	Immediate		Delay	
	N	Q	N	Q
Ordered recall	32.5	29.2	20.0	25.8
Free recall	55.0	48.3	43.3	47.9

four positions, i.e. serial positions 5+6+7+8 (q=20; df 3,152; $p < .01$) or the third four positions i.e. positions 9+10+11+12 (q=16.63; df 3,152; $p < .01$) and significantly more words were recalled from positions 9+10+11+12 than from positions 5+6+7+8 (q=3.36; df 3,152; $p < .05$).

The first order interaction SP x R1 (F=3.30; df 2,152; $p < .05$) was analysed further for simple main effects following procedure outlined by Kirk (1969) and the summary table for this is given in Table 13b.

Table 13a

Anova - Noise x Serial position x Retention Interval for Ordered Recall Scores (Trial 1)

Source	SS	df	MS	F
Total	367.65			
Between subjects	65.65	79		
Noise (N)	0.15	1	0.15	< 1
Retention interval (Rl)	6.01	1	6.01	7.95**
N x Rl	2.02	1	2.02	2.67ns
Subj. w gps.	57.47	76	0.756	
Within subjects	302	160		
Serial position (SP)	177.02	2	88.51	115.38**
N x SP	0.18	2	0.09	< 1
SP x Rl	5.07	2	2.53	3.30*
N x SP x Rl	3.10	2	1.55	2.02ns
SP x Subj. w gps.	116.63	152	0.767	

Table 13b

Summary Table for Simple Main Effects (SP x Rl) - Trial 1

Source	SS	df	MS	F
SP at Rl_1 (Imm)	83.27	2	41.63	54.28**
SP at Rl_2(Delay)	98.82	2	49.41	64.42**
SP x Subj. w gps.			0.767	
Rl at SP_1	0.45	1	0.45	<1
Rl at SP_2	0.11	1	0.11	<1
Rl at SP_3	10.51	1	10.51	13.77**
Error term		228	0.763	

From Figure 6 it can be seen that the major effect of delay is to substantially reduce the amount recalled in serial positions 9-12 which was expected from previous research. The interaction between NxRl did not reach significance although it can be seen from Table 12 that performance in N is better than that in Q for immediate recall but worse for delayed recall.

A summary of the results of the analysis of the free recall data is presented in Table 14a, which shows a significant main effect of retention interval ($F=4.49$; df 1,75; $p < .05$) and of serial position ($F=45.83$; df 2,152; $p < .01$). As with the ordered recall data, performance was better when recall was immediate rather than delayed. Comparisons between means for the main effect of SP using Tukey's method showed that significantly more words were recalled in serial positions 1-4 than in positions 5-8 ($q=11.42$; df 3,152; $p < .01$) or in positions 9-12 ($q=11.42$; df 3,152; $p < .01$). The mean number of words recalled from positions 5-8 was identical to that from positions 9-12. The interaction NxRl also reached significance ($F=3.91$; df 1,76; $p < .05$) and once again this was analysed further for simple main effects and the summary table for this is given in Table 14b. The interaction is also illustrated in Figure 7 which shows that immediate recall is better in noise than in quiet whereas the reverse is the case for delayed recall.

The number of intrusion errors i.e. words which subjects recalled but which were not in the list presented, were also recorded and Table 15 shows the mean number of intrusion errors in each condition for Trial 1 only. A 2x2 (Noise/quiet; immediate/delayed) analysis of variance was

Figure 6 Figure showing probability of recall as a function of serial position (ordered recall) Trial 1 - Experiment 2.

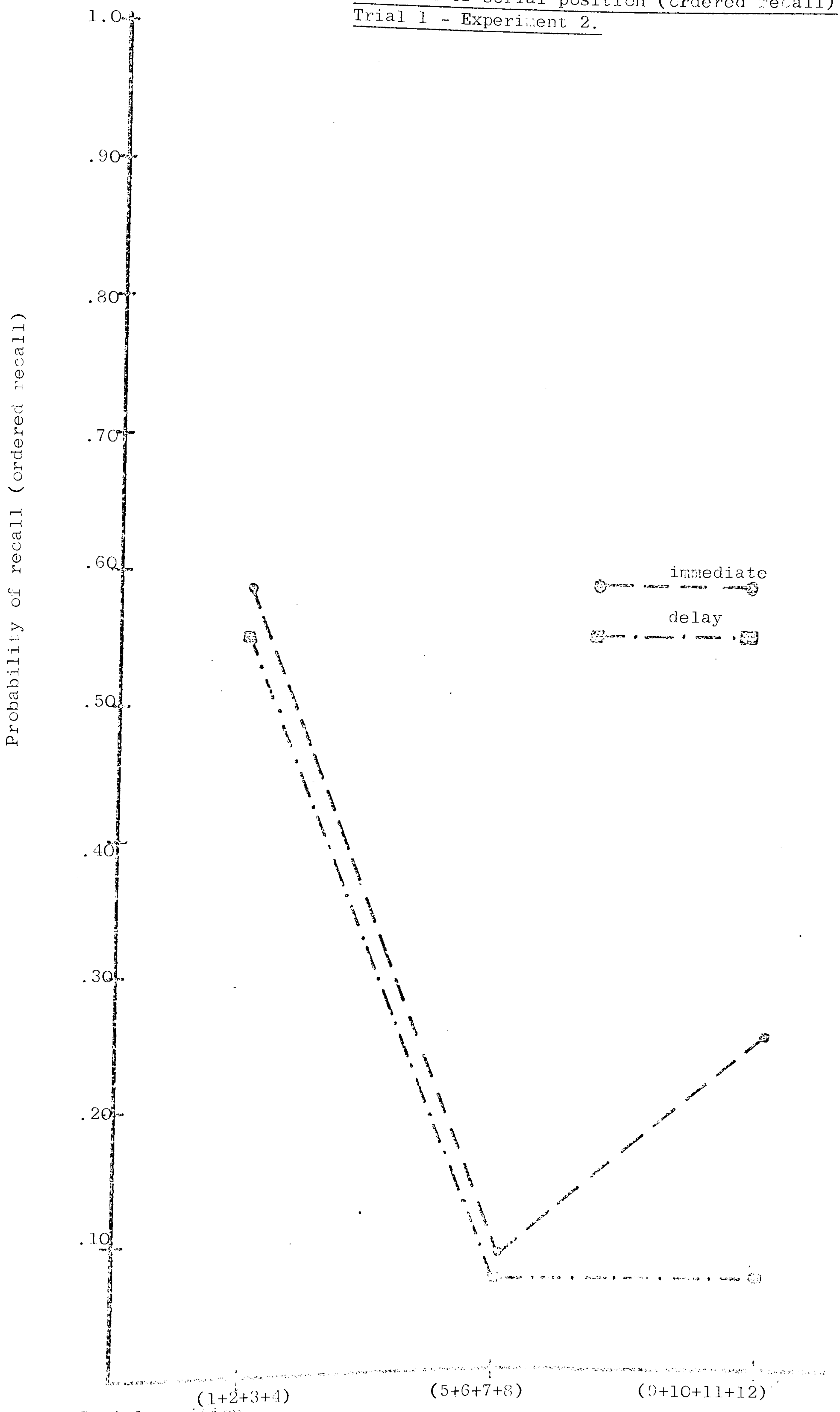


Table 14a

Anova - Noise x Serial position x Retention interval for free recall scores (Trial 1)

Source	SS	df	MS	F
Total	338.3			
Between subjects	66.3	79		
Noise (N)	0.1	1	0.1	<1
Retention interval (Rl)	3.5	1	3.5	4.49*
N x Rl	3.05	1	3.05	3.91*
Subj. w gps.	59.65	76		
Within subjects	272.0	160		
Serial position (SP)	100.83	2	50.41	45.83**
N x SP	1.44	2	0.72	<1
SP x Rl	1.04	2	0.52	<1
N x SP x Rl	0.69	2	0.34	<1
SP x Subj. w gps.	168.0	152	1.10	

Table 14b

Summary Table for Simple Main Effects (N x Rl) - Trial 1

Source	SS	df	MS	F
N at Rl_1 (Immediate)	2.14	1	2.14	2.74ns
N at Rl_2 (Delay)	1.01	1	1.01	1.29ns
Rl at N_1 (Noise)	6.54	1	6.54	8.38**
Rl at N_2 (Quiet)	0.01	1	0.01	<1
Error term	59.65	76	0.78	

Figure 7 Figure showing the probability of recall as a function of retention interval (ordered recall) - Trial 1 - Experiment 2.

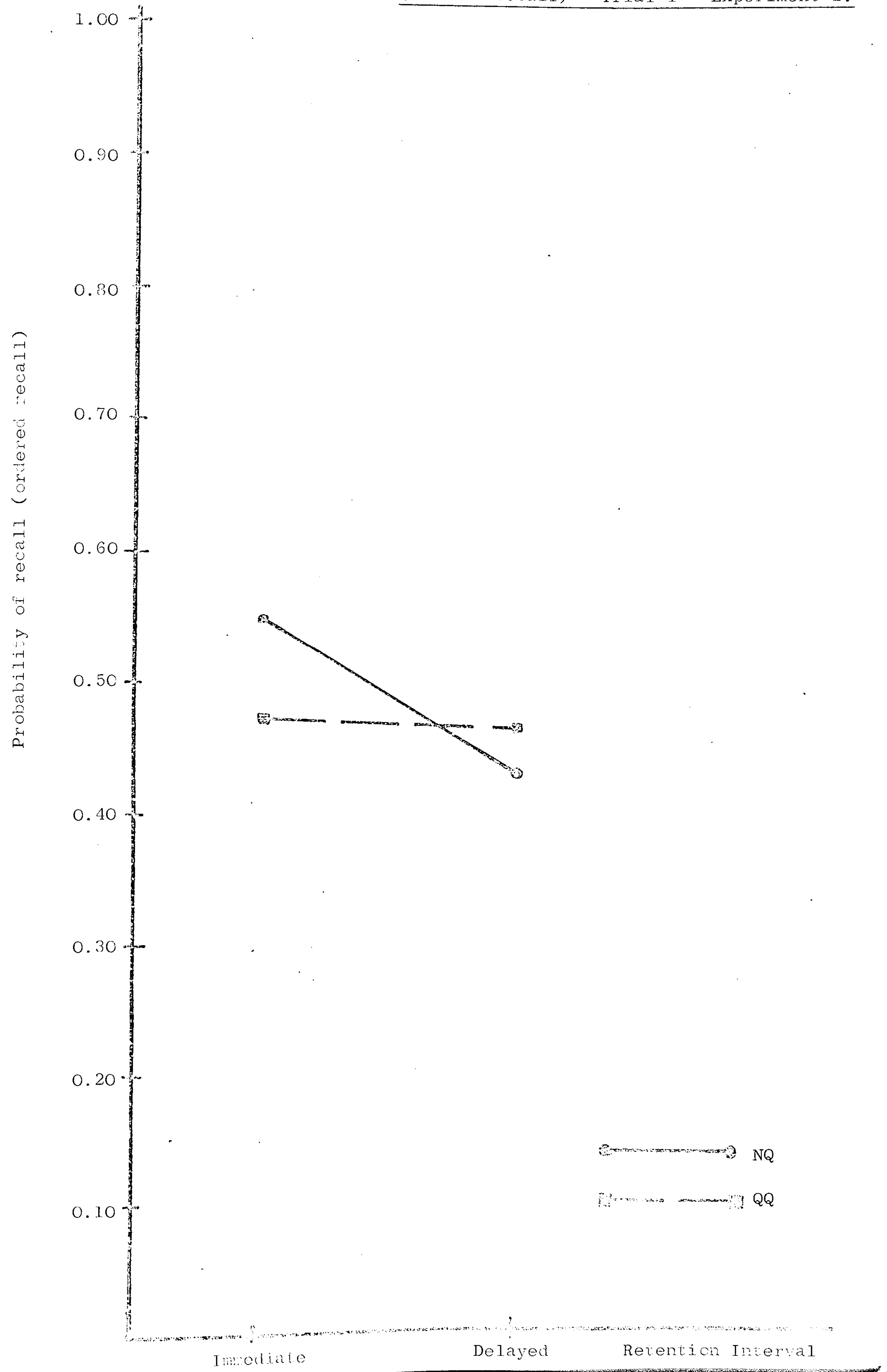


Table 15

Mean number of Intrusions in Trial 1 only

	Noise	Quiet
Immediate recall	0.35	0.85
Delayed recall	0.60	0.95

Table 16

Anova - Noise x Retention interval for instrusion errors (Trial 1)

Source	SS	df	MS	F
Noise (N)	3.61	1	3.61	5.23*
Retention interval (R1)	0.61	1	0.61	< 1
N x R1	0.12	1	0.12	< 1
Within cell	52.85	76	0.69	

carried out on these data and the summary table for this analysis is presented in Table 16 , which shows a significant main effect of noise ($F=5.23$; df 1,76; $p < .05$) which results in more intrusion errors occurring in quiet than in noise.

(iii) Analysis of Trials 3-12

For this section of the analysis of results the first two lists of words presented to subjects were considered practice trials and the results of these are not used in the following analyses.

Once again recall performance was assessed in two ways: i) by considering the number of words recalled in the correct serial positions and ii) by considering the number of words correctly recalled irrespective of serial positions and a summary of these are shown in Table 17
A 2x3x2 (noise/quiet; serial positions 1-4; 5-8; 9-12; immediate/delay) analysis of variance with repeated measures on the second factor was carried out on both the ordered and free recall data. A summary of the results of the analysis of the ordered recall data is presented in Table 18a, which shows a significant main effect of retention interval ($F=31.03$; df 1,76; $p < .01$) and serial position ($F=115.89$; df 2,152; $p < .01$). Performance was better when recall was immediate rather than delayed. Comparisons between means for the main effect of serial position using Tukey's method showed that significantly more words were recalled in the first four positions in the list than in positions 5-8 ($q=21.49$; df 3,152; $p < .01$) or positions 9+10+11+12 ($q=8.17$; df 3,152; $p < .01$) and significantly more were recalled in positions 9+10+11+12 than in positions 5-8 ($q=13.32$; df 3,152; $p < .01$).

Table 17

% Correct in N and Q for Immediate and Delayed Recall (ordered and free) for trials 3-12.

	Immediate		Delay	
	N	Q	N	Q
Ordered recall	40.4	33.3	18.8	26.1
Free recall	52.8	50.0	37.9	40.9

Table 18a

Anova - Noise x Serial position x Retention interval for ordered recall scores

Source	SS	df	MS	F
Between subjects	7,402.87	79		
Noise (N)	0.04	1	0.04	1
Retention interval (Rl)	2,001.04	1	2,001.04	31.03**
N x Rl	501.68	1	501.68	7.78**
Subjs. w gps.	4,900.11	76	64.47	
Within subjects	11,692.0	160		
Serial position (SP)	5,286.93	2	2,643.46	115.89**
N x SP	135.66	2	67.83	2.97+
SP x Rl	2,787.76	2	1,397.88	61.28**
N x Rl x SP	14.11	2	7.05	1
SP x Subj. w gps.	3,468.14	152	22.81	

The interactions noise x retention interval (F=7.78; df 1,76; p < .01) and serial position x retention interval (F=61.28; df 2,152- p < .01) were also significant and these were analysed further for simple main effects, following the procedure outlined by Kirk (1969) and the summary tables for these are given in Tables 18b and 18c. From Figure 8 the interaction between noise and retention interval can be interpreted as showing that performance in N is better than that in Q (though not significantly so) when recall is immediate but significantly worse than that in Q when recall is delayed. The interaction between serial position and retention interval is illustrated in Figure 9 from which it can be seen that the major effect of delay is to substantially reduce the amount recalled in serial positions 9-12. The interaction between N and SP just failed to reach significance (F=2.97; df 2,152) but is illustrated in Figure 10 from which it can be seen that N tends to improve performance on the latter SP's, but has a slightly detrimental effect on the early positions.

A summary of the results of the analysis of the free recall data is presented in Table 19a, which shows a significant main effect of retention interval (F=29.95; df 1,76; p < .01) and serial position (F=73.45; df 2,152; p < .01). As with the ordered recall data, performance was better when recall was immediate rather than delayed. Comparisons between means for the main effect of serial position using Tukey's method showed that significantly more words were recalled in the first four positions than in positions 5-8 (q-16.30; df 3,152; p < .01) or positions 9-12 (q=3.57; df 3,152; p < .05) and significant more were recalled in positions 9-12 than in positions 5-8 (q=12.72; df 3,152; p < .01). The interactions Noise x Serial position (F=5.00; df 3,152; p < .01).

Table 18b

Summary Table for Simple Main Effects (N x Rl)

Source	SS	df	MS	F
Between subjects				
N at Rl_1	246.53	1	246.53	3.82+
N at Rl_2	255.21	1	255.21	3.96*
Rl at N_1	2,253.33	1	2,253.33	34.95**
Rl at N_2	249.41	1	249.41	3.98 +
Subj. w gps.	4,900.11	76	64.47	

Table 18c

Summary Table for Simple Main Effects (SP x Rl)

Source	SS	df	MS	F
SP at Rl_1	4,353.65	2	2,176.82	95.43**
SP at Rl_2	3,721.05	2	1,860.52	81.57**
B x Subj. w gps.	3,468.14	152	22.81	
Rl at SP_1	5.00	1	5.00	<1
Rl at SP_2	40.61	1	40.61	1.11ns
Rl at SP_3	4,743.20	1	4,743.20	129.24**
Error term		228	36.70	

Figure 8 Figure showing probability of recall as a function of retention interval (ordered recall) Trials 3-12 - Experiment 2.

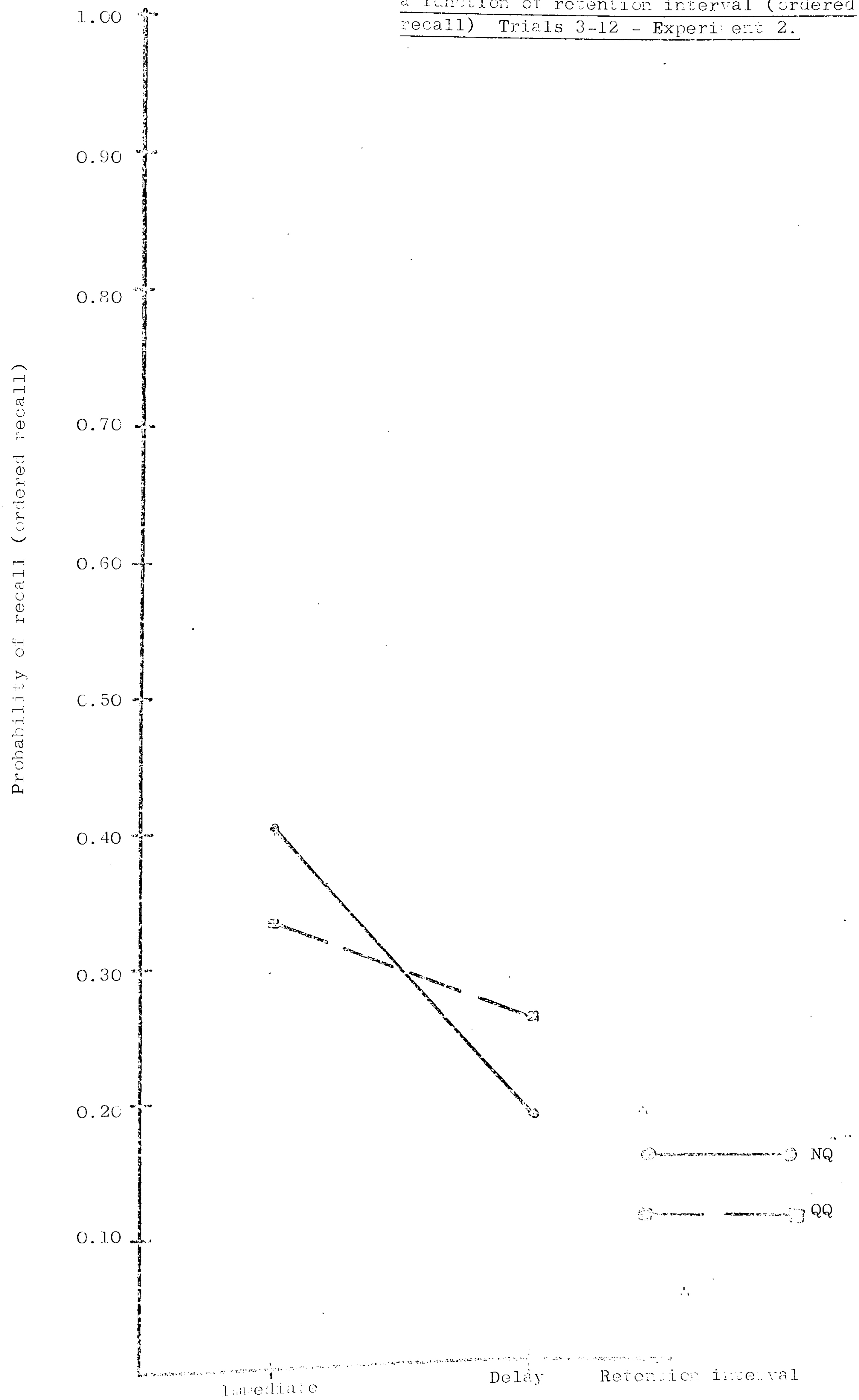


Figure 9 Figure showing probability of recall as a function of serial position (ordered recall) Trials 3-12.- Experiment 2.

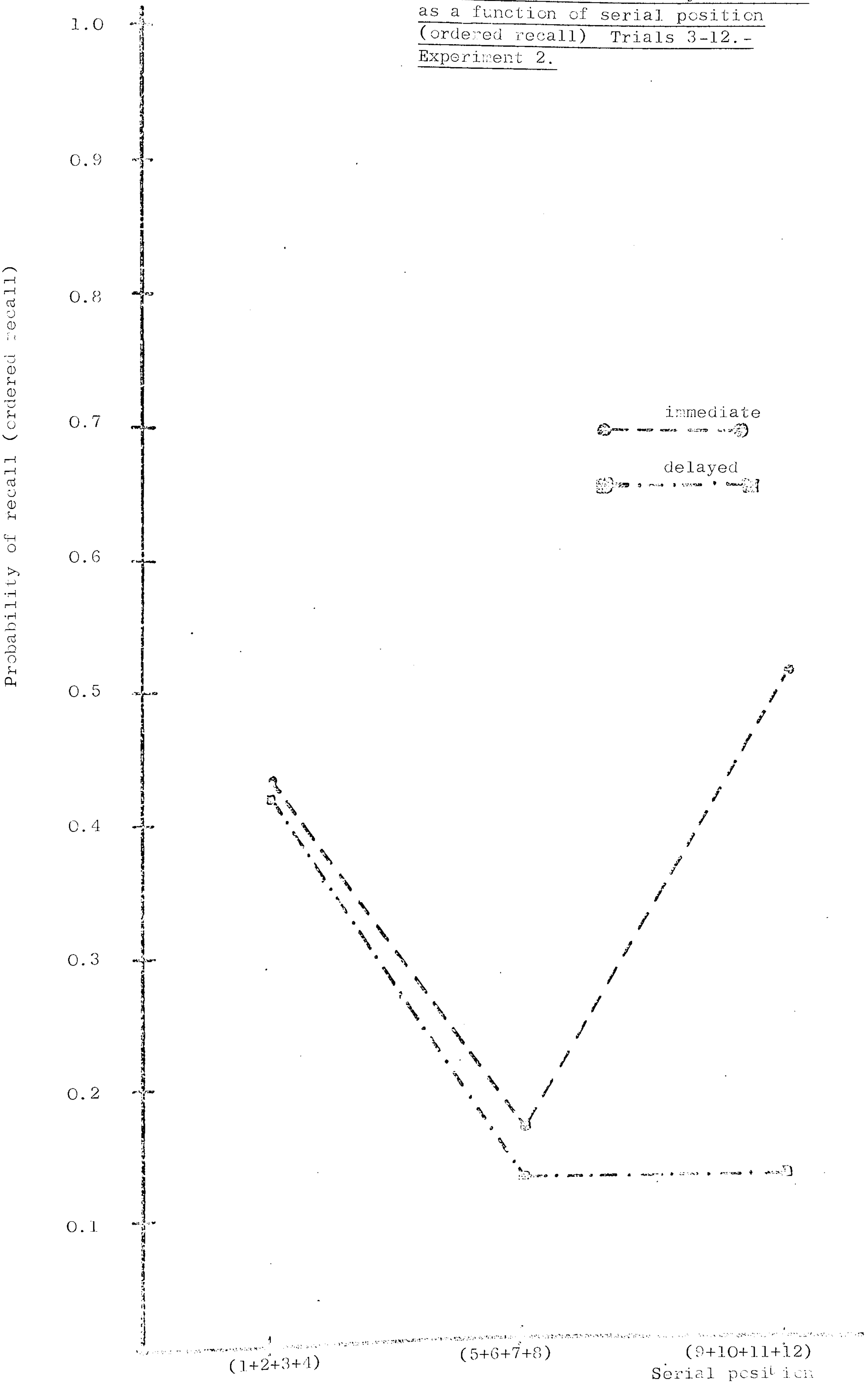


Figure 10 Figure showing probability of recall as a function of serial position (ordered recall) Trials 3-12 - Experiment 2.

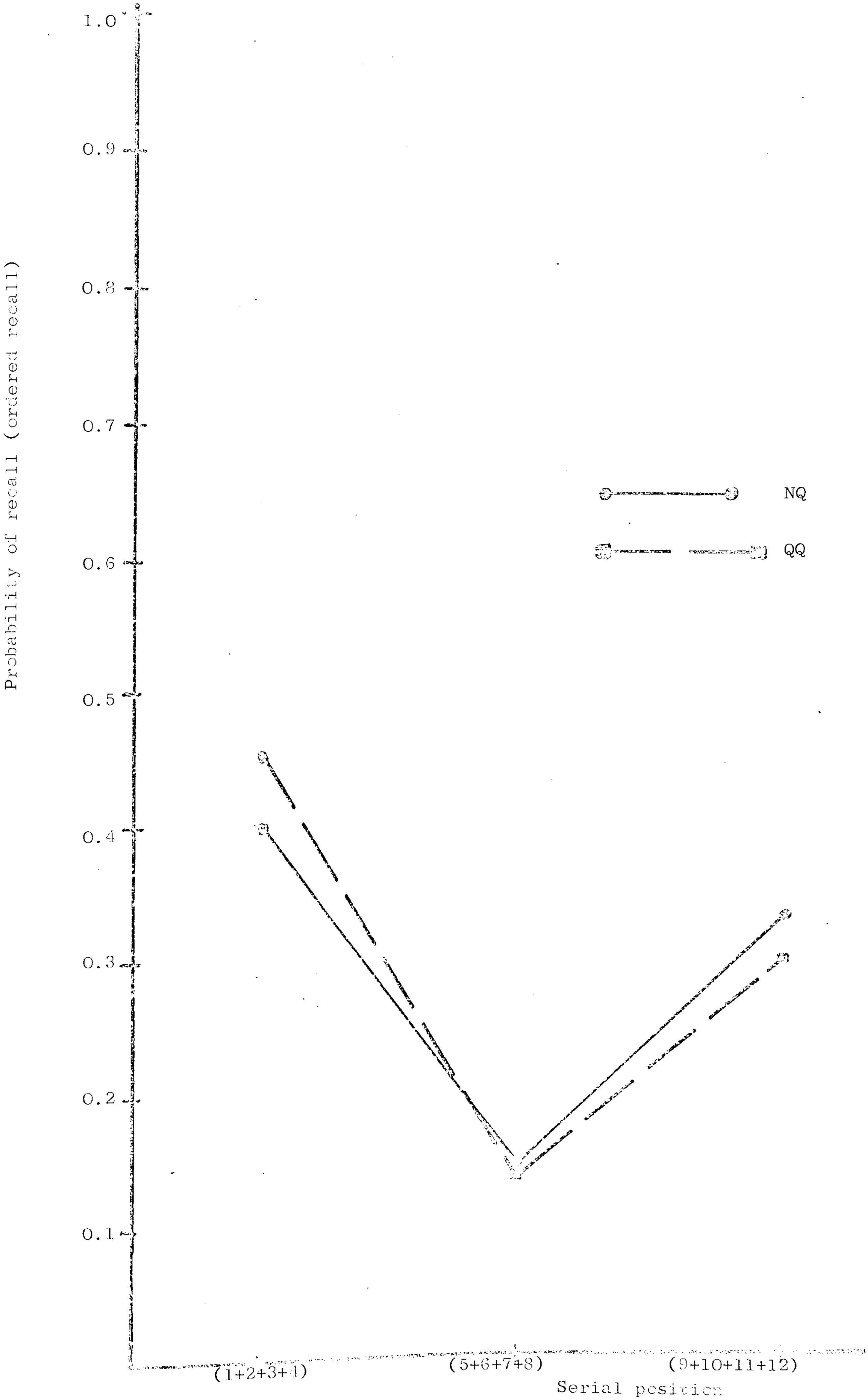


Table 19a

Anova - Noise x Retention interval x Serial position for free recall scores

Source	SS	df	MS	F
Between subjects	5,024.53	79		
Noise (N)	0.03	1	0.03	<1
Retention interval (Rl)	1,396.83	1	1,396.83	29.95**
N x Rl	82.85	1	82.85	1.78ns
Subj. w gps.	3,544.82	76	46.64	
Within subjects	8,558.13	160		
Serial position (SP)	3,424.29	2	1,712.14	73.45**
N x SP	233.11	2	116.55	5.0**
SP x Rl	1,332.31	2	666.15	28.58**
N x SP x Rl	25.19	2	12.59	<1
SP x Subj. w gps.	3,543.23	152	23.31	

df 2,152; $p < .01$) and serial position x retention interval were also significant and once again these were analysed further for simple main effects and the summary tables for these are given in Tables 19b and 19c. The interaction between noise and retention interval was not significant for the free recall data, although a similar tendency for performance to be better than that in quiet when recall was immediate and worse than that in quiet when recall was delayed was observed. The interaction between noise x serial position is illustrated in Figure 11 and that between serial position x retention interval in Figure 12. Performance in noise was significantly worse than that in Q in serial positions 1-4, while in the other positions the reverse was the case, although the differences were not significant. As with the ordered recall data, the major effect of delay is to impair performance in the recency part of the SP curve.

As with the results of Trial 1, the number of intrusion errors were also recorded and Table 20 shows the mean number of intrusion in each condition. A 2x2 (noise/quiet; immediate/delayed) analysis of variance was carried out on these data and the summary table for this analysis is presented in Table 21 , which shows a significant main effect of noise ($F=4.78$; df 1,76; $p < 0.05$) which results in more intrusion errors occurring in quiet than in noise. The first order N x Rl approached significance ($F=3.60$; df 1,76; $p < .10$) and this interaction is illustrated in Figure 13 from which it can be seen that in noise, more intrusion errors occur in immediate recall than in delayed recall whereas in quiet, the reverse is the case.

Table 19b

Summary Table for Simple Main Effects (N x SP)

Source	SS	df	MS	F
Noise at SP_1	132.61	1	132.61	4.26*
Noise at SP_2	1.51	1	1.51	$<$ 1
Noise at SP_3	99.01	1	99.01	3.18+
Error term		228	31.09	
SP at N_1	1,549.85	2	774.92	33.24**
SP at N_2	2,107.55	2	1,053.77	45.21**
SP x subj. w gps.	3,543.23	152	23.31	

Table 19c

Summary Table for Simple Main Effects (SP x Rl)

Source	SS	df	MS	F
SP at Rl_1	2,904.65	2	1,452.32	62.3**
SP at Rl_2	1,851.95	2	925.97	39.72**
Rl at SP_1	25.31	1	25.31	1.08ns
Rl at SP_2	70.31	1	70.31	3.02+
Rl at SP_3	2,633.51	1	2,633.51	112.98**
SP x subj. w gps.	3,543.23	152	23.31	

Figure 11 Figure showing probability of recall as a function of serial position (free recall) Trials 3-12 - Experiment 2.

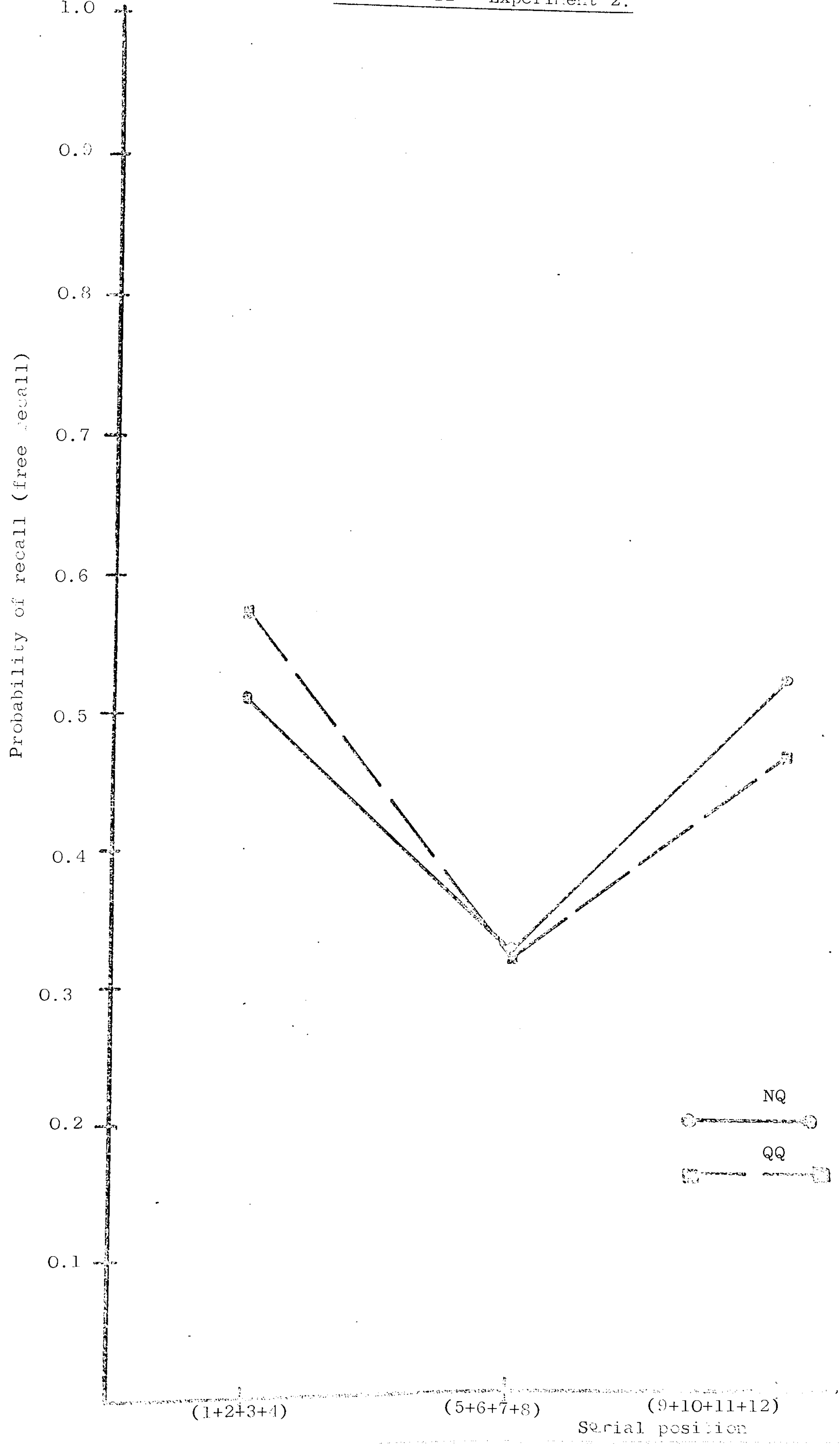


Figure 12 Figure showing the probability of recall as a function of serial position (free recall) Trials 3-12 - Experiment 2.

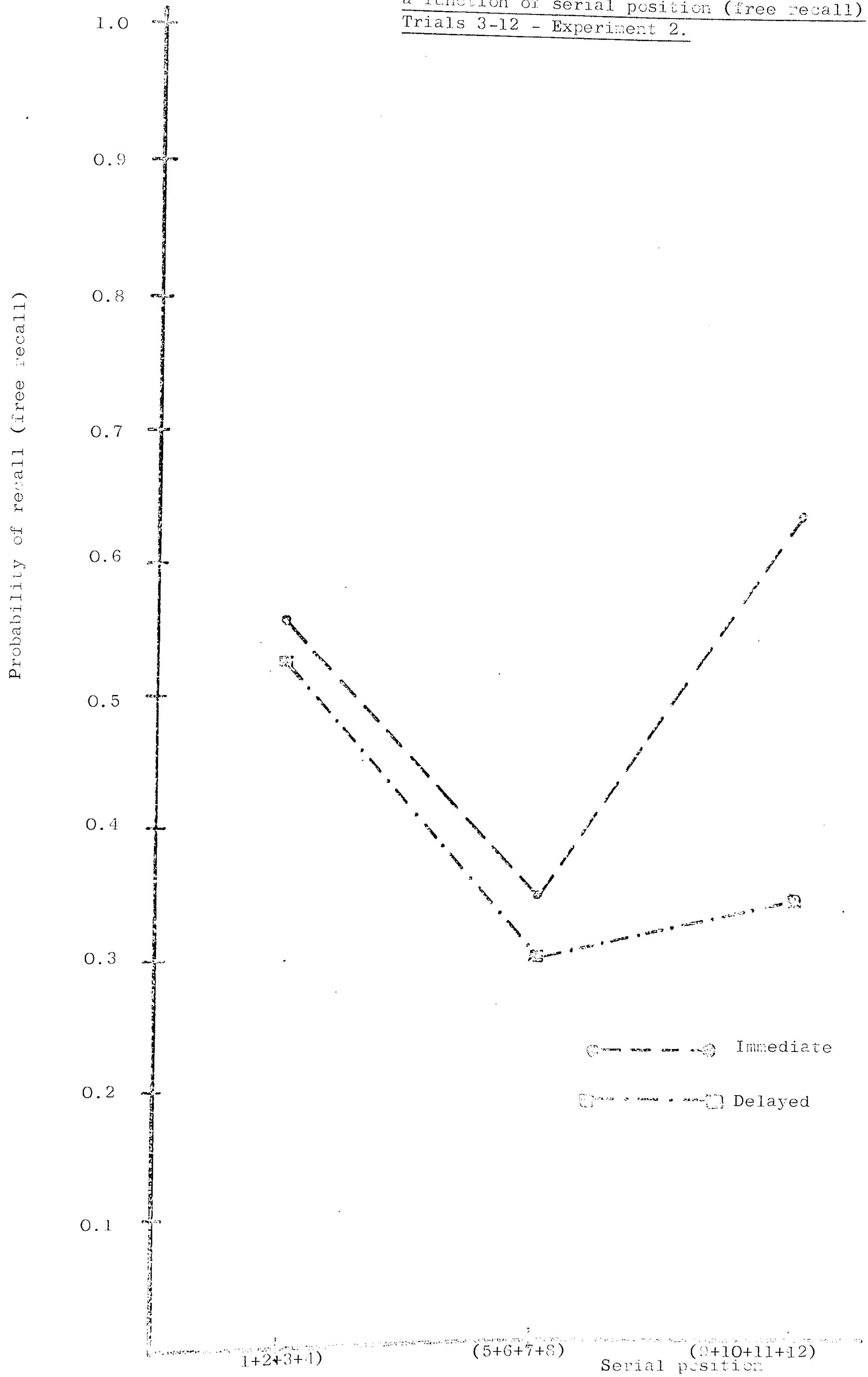


Table 20

Mean Number of Intrusion Errors in Trials 3-12

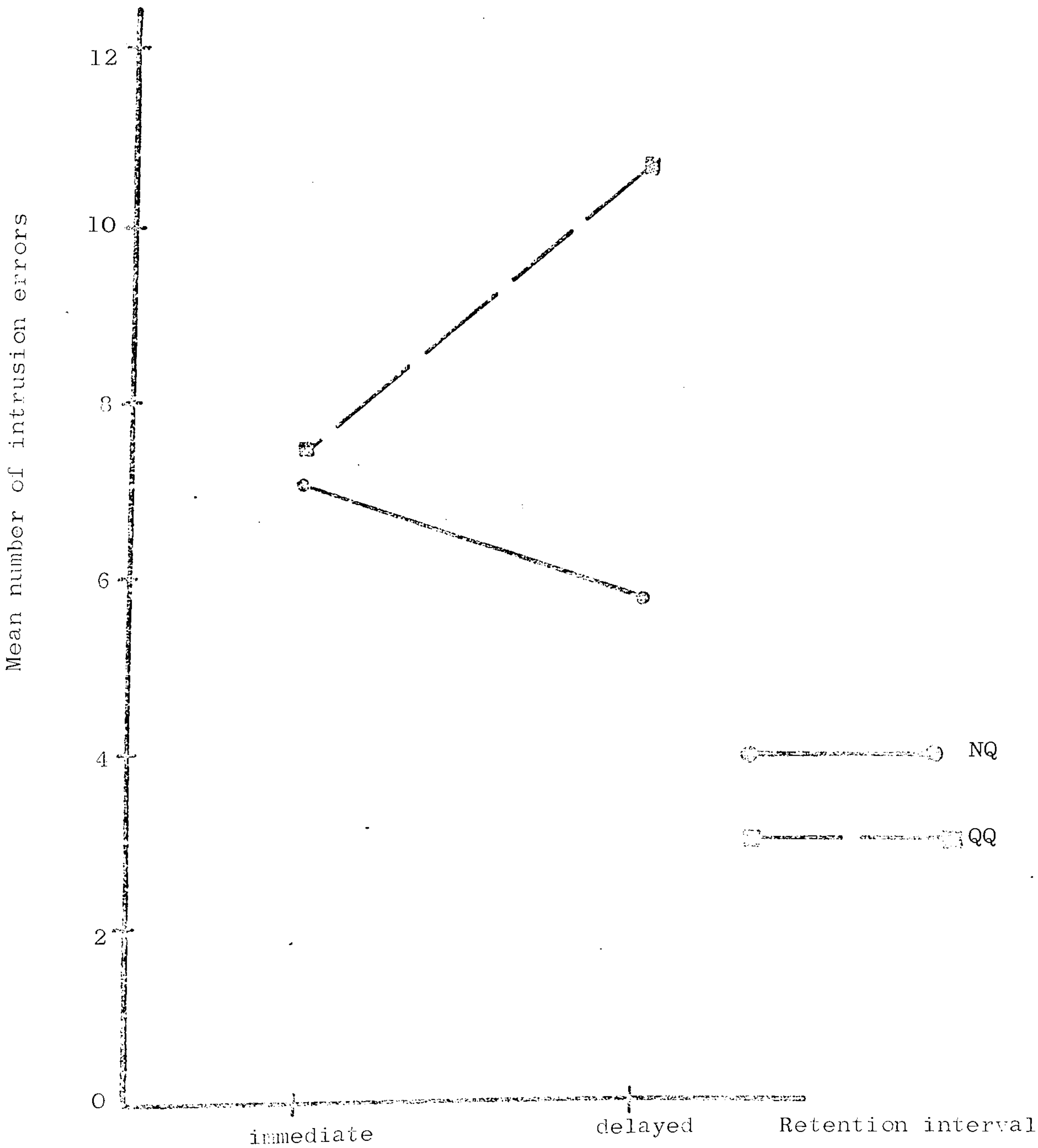
	Noise	Quiet
Immediate	7.10	7.45
Delayed	5.85	10.80

Table 21

Anova - Noise x Retention interval for instrusion errors (trials 3-12)

Source	SS	df	MS	F
Noise (N)	140.44	1	140.44	4.78*
Retention interval (R1)	22.04	1	22.04	< 1
N x R1	105.82	1	105.82	3.60+
Within cell	2,232.50	76	29.37	

Figure 13 Figure showing the mean number of intrusion errors in noise and quiet as a function of retention interval



4.2.1 Comparison between Trial 1 and Trials 3-12

Table 22 shows the mean percentage correct for Trial 1 only and for Trials 3-12 in the various experimental conditions. Immediate recall performance tends to improve from Trial 1 to Trials 3-12 for ordered recall in both noise and quiet while for free recall, performance tends to improve from Trial 1 to Trials 3-12 in quiet and deteriorate in noise. Delayed recall performance, on the other hand, tends to deteriorate from Trial 1 to Trials 3-12 for free recall in both noise and quiet while for ordered recall, performance deteriorates in noise and improves slightly in quiet. However, as can be seen from the table, all these differences are very small. The serial position curves for Trial 1 and Trials 3-12 for each experimental condition were also compared and these are illustrated in diagrams 14, 15, 16 and 17.

4.3 Discussion

The principal aim of the experiment was to test the prediction that high arousal reduces the 'depth' of processing of to-be-remembered material and on the whole the results tend to confirm this prediction since for immediate free recall, N results in better performance in the recency portion of the SP curve, but worse performance in the early parts of the list and for delayed recall, performance in N is worse in all SP's.

Although the analysis of the ordered recall data showed no overall effect of noise the significant interaction between noise and retention interval revealed that performance in N tended to be better than that

Table 22

The Mean % correct for Trial 1 only and Trials 3-12 Inclusive

	Immediate Recall			
	Trial 1		Trials 3-12	
	N	Q	N	Q
Ordered recall	32.5	29.2	40.4	33.3
Free recall	55.0	48.3	52.9	50.0

	Delayed Recall			
	Trial 1		Trials 3-12	
	N	Q	N	Q
Ordered recall	20.0	25.8	18.8	26.1
Free recall	43.3	47.9	37.9	40.9

Figure 14 Figure showing the probability of immediate recall (ordered recall) as a function of serial position for Trial 1 and Trials 3-12 - Experiment 2.

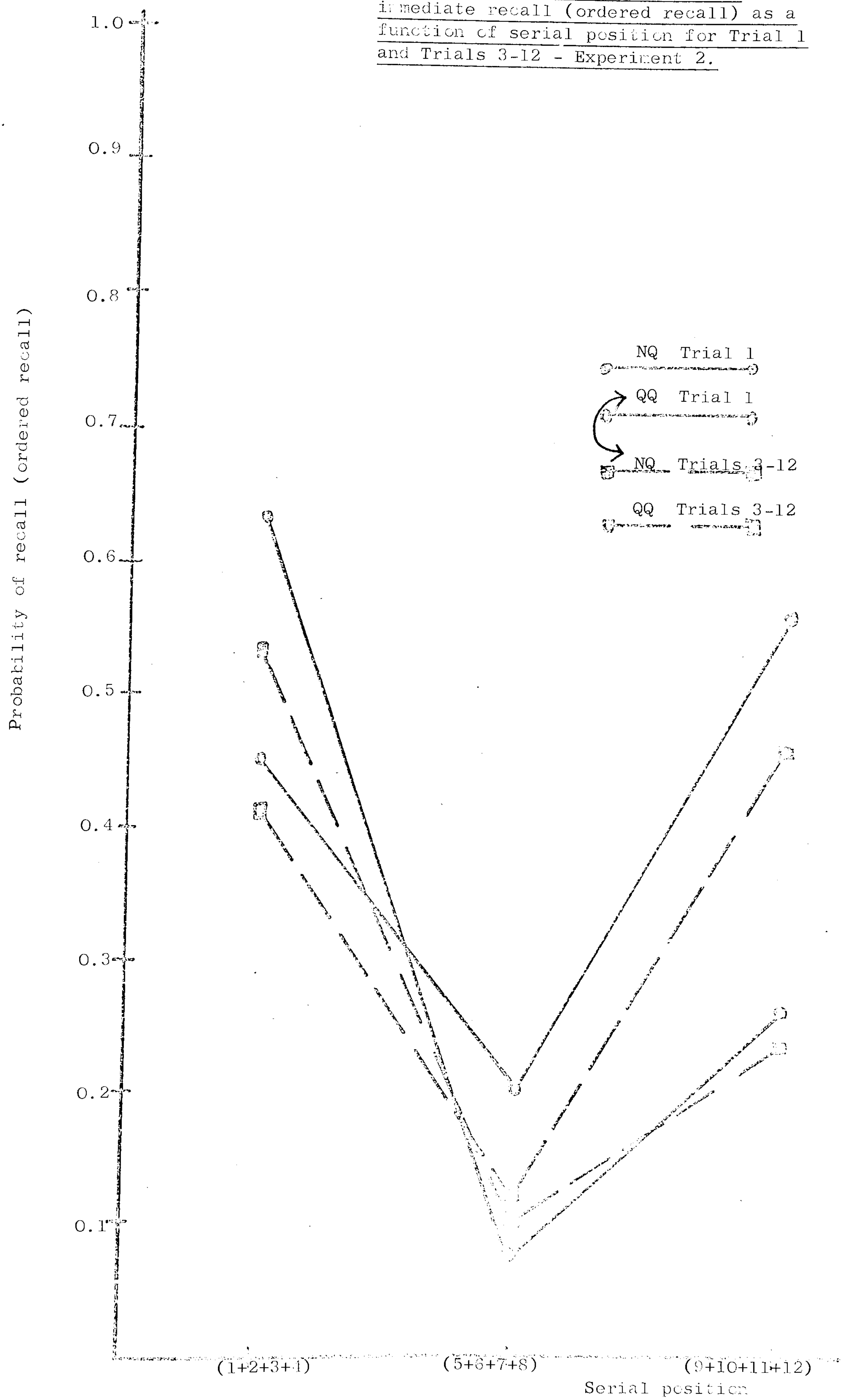


Figure 15 Figure showing the probability of delayed recall (ordered recall) as a function of serial position for Trial 1 and Trials 3-12 - Experiment 2.

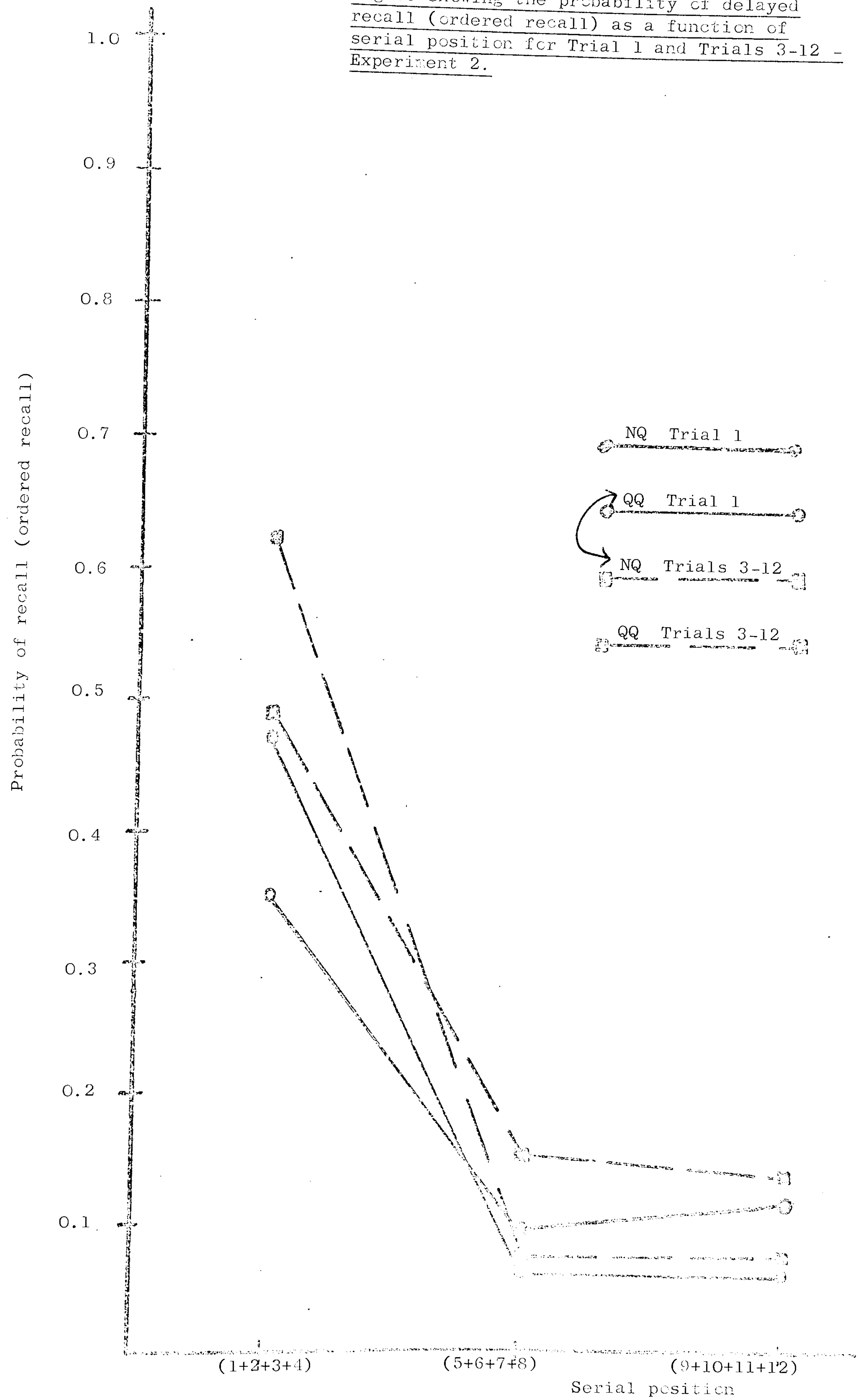


Figure 16 Figure showing the probability of immediate recall (free recall) as a function of serial position for Trial 1 and Trials 3-12 - Experiment 2.

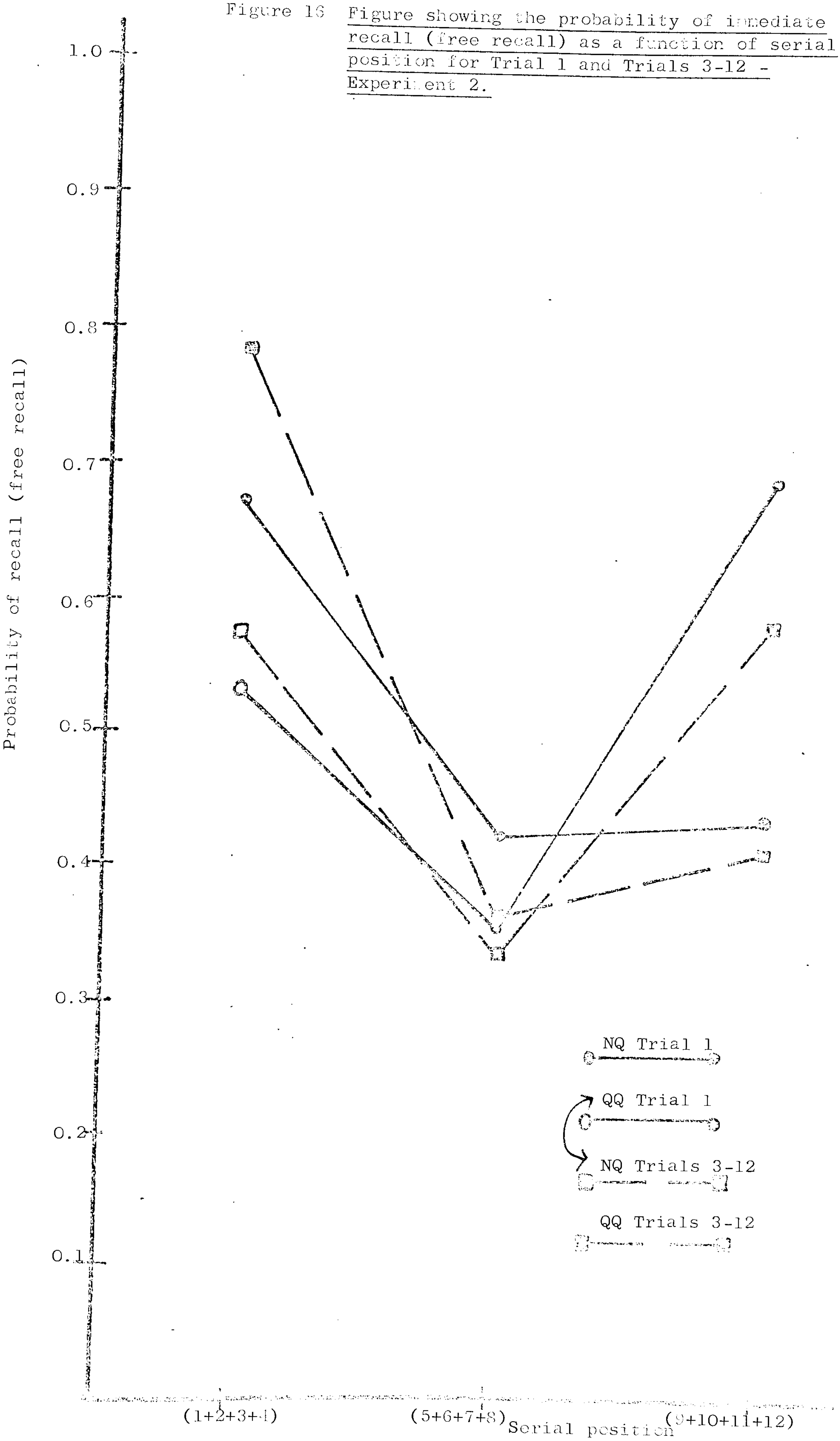
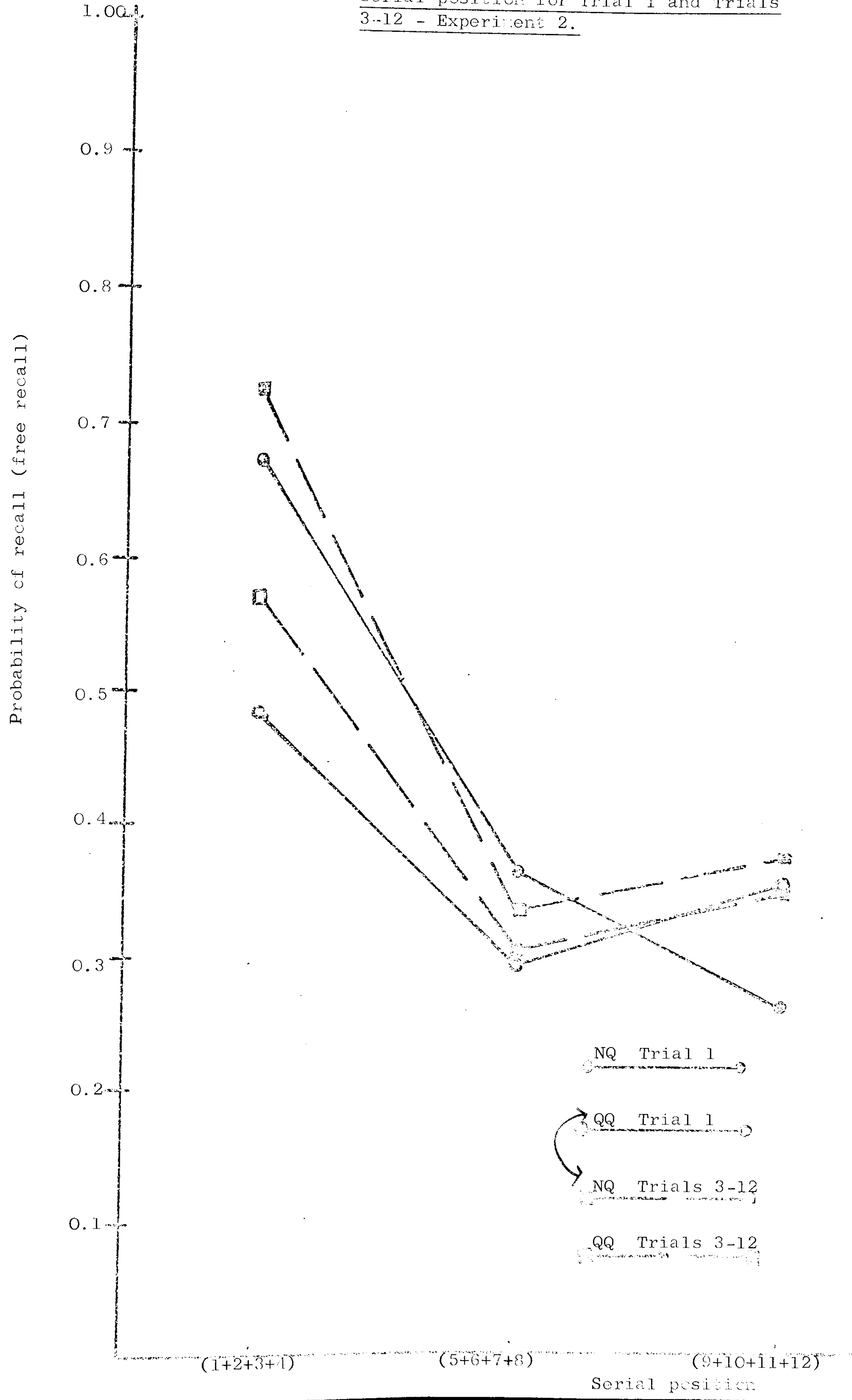


Figure 17 Figure showing the probability of delayed recall (free recall) as a function of serial position for Trial 1 and Trials 3-12 - Experiment 2.



in Q for immediate recall, while the reverse was the case for delayed recall. The former comparison, which just failed to reach significance would thus seem to be in agreement with the results of Hockey and Hamilton (1970) which suggest that more order information is stored in noise than in quiet. However, the analysis of the free-recall data, which again showed no overall effect of noise, also revealed a non-significant interaction between N and retention interval, although the tendency for performance to be better in N than Q for immediate recall and the reverse for delayed recall, was in the same direction as that for the ordered recall data.

The interaction between noise and SP was significant for the free-recall data but just failed to reach significance for the ordered recall data. However, since this interaction between N and SP for both the main analyses resulted from combined data from the immediate and delayed recall conditions, the SP curves for these two conditions are illustrated separately in Figures 14, 15, 16 and 17. For the immediate ordered recall condition, performance in N tended to be better than that in Q at all SP's, but the difference is greatest on the final positions while for the delayed ordered recall condition performance tended to be better in Q than in N at all SP's, although this difference is greatest on the early positions. Comparisons between performance scores in N and Q at each SP reveal that only the difference between N and Q in the delayed condition at SP_1 is significant, although the difference approaches significance for the delayed condition at SP_2 and for the immediate condition at SP_3.

For the free recall data, the expected finding of better performance in N on the recency portion of the curve for immediate recall was obtained, the comparison between N and Q being significant on SP_3. Since, according to Craik and Lockhart (1972) the final list items in a free recall task are only encoded at the phonemic level, this result suggests that N is beneficial for the 'less-deep' i.e. Type I processing. The early items in the list, which need to be subjected to semantic coding for relatively successful recall tend to be less well recalled in N. This could be due to the fact that N has a detrimental effect on semantic processing which would be in line with the various results obtained by Schwartz (according to Eysenck). However, a possible alternative explanation may be that subjects working in N are less inclined to adopt a strategy of semantic processing of the early items and merely encode these at the same less-deep level(s), as with the final items, a strategy which would presumably result in inferior performance over the initial portion of the SP curve. It has been suggested that processing to deeper levels requires more effort (Jacoby, 1973) and therefore since working in noise also demands more effort (Helper, 1957; Conrad, 1973) the adoption in N of the strategy requiring the least effort (i.e. Type I processing) would seem a reasonable one.

It has been pointed out by Jacoby and Bartz (1972) that the type of processing adopted by S is under his own control and if he anticipates a delayed recall after a rehearsal-preventing activity then deeper processing of the terminal items, as well as the initial items, is required and they interpret their results as showing that subjects encode words semantically in order to survive the filled delays. If delayed recall is a measure of recall after semantic processing and the work of Schwartz suggests decreased processing of semantic information in N, then the detrimental effects of noise on delayed recall are to be expected. From Figure 16 it can be seen that performance in N is worse than that in Q at SP_1 and comparisons between means revealed this different to be significant.

The usual memory result of better performance for immediate than delayed recall for both ordered and free data was obtained, with the main advantage of immediate recall being due to superior recall from terminal positions.

4.4 Conclusion

The immediate recall condition of the present experiment resulted in similar findings to those of Experiment 1, with working in noise resulting in improved performance on the recency part of the serial position curve, but a tendency for a deterioration in performance on earlier serial positions. These results were discussed in terms of the adoption of less deep levels of processing by subjects working in noise. For the delayed recall condition, however, overall performance in noise was significantly worse than that in quiet and this was mainly due to impaired performance on early serial positions. Once again the results were discussed in terms of levels of coding and it was suggested that working in noise either results in subjects adopting less deep levels of coding even for delayed recall or that it impairs deeper levels of processing. However, since subjects knew in advance that recall would be delayed, the second possibility seems more reasonable.

CHAPTER 5

NOISE AND RECOGNITION MEMORY

In the previous experiment it was suggested that the differential effects of noise on the serial position curves for immediate and delayed recall might be the result of noise differentially affecting Type I and Type II coding. A study by Schwartz (cited by Eysenck, 1976) also required the free recall of either unrelated words, phonemically related words or semantically related words. High-, medium-, and low-arousal conditions were obtained by manipulating the intensity of white noise during list presentation. Recall was either immediate or 2 minutes later. A highly significant interaction between arousal and type of material was obtained, with high arousal improving recall of phonemically related and control material, but having no effect on semantically related words. Since more details of the experiment are not given, for example SP curves, it is difficult to compare it with the previous experiment. However, according to Eysenck, Schwartz suggested that the differential effects of arousal on memory for phonemically and semantically related material are due to processes operating at retrieval, and although the paradigms he used involved the manipulation of arousal at the time of input only, he is not alone in postulating effects of arousal on retrieval (Eysenck, 1974; 1976).

A result of the structural approach to memory is the distinction between storage and retrieval i.e. the storage of information and its retrieval from the memory store are two theoretically separate processes (Melton, 1963). However, they are much more difficult to separate experimentally, although a review by McCormack (1972) suggests that the recognition memory literature is consistent with a two process notion whereby recognition may be primarily characterised by a storage process, while recall is considered to involve an additional process, that of retrieval.

Two examples of the two process approach are the theories of Kintsch (1970b) and Anderson and Bower (1972). Compared with earlier accounts of the differences between recognition and recall, such as those which distinguish the two retention measures in terms of a different threshold, the two process theory appears to have several advantages. Its additional degree of freedom allows it to account readily for results which show that certain variables e.g. word frequency, incidental v. intentional instructions, influence recall and recognition differently. If arousal does affect retrieval, rather than the processes of encoding and storage, and if recognition involves only a minimal retrieval component, then arousal should affect recall to a greater extent than recognition. A study by Eysenck (1975) obtained this expected differential effect of arousal on recall and recognition and interpreted the finding as indicating that arousal affected the retrieval component of recall.

However, the two-stage theory has recently received a fair amount of criticism (e.g. Tulving, 1976) and one of the main objections derives from the known facts about context effects in recognition memory. A number of experiments have been reported showing that recognition of the study list item depends on the relation between its context at the time of study and at the time of its test (Light and Carter-Sobell, 1970; Marcel and Steel, 1973; Thomson, 1972). Context is usually defined in terms of the presence of other items to which the subject attends. The typical findings are that the changes in the context between study and test produce an impairment in recognition performance. If recognition results from a simple decision about the occurrence information attached to the items representation in permanent memory, then the context of a to-be-remembered item and its literal copy at test should not be important. The two-stage theory does not have an answer to this question and this has resulted in a modification of the two-stage theory (Anderson and Bower, 1974) which assumes that recognition sometimes fails because the information available in the store cannot be found, that is, because of the failure of retrieval. Thus the modified theory implies that recognition too, may require both retrieval and decision. Kintsch's (1974) new two-stage theory also suggests that retrieval is involved in recognition. The relaxation of initial restrictions has enabled the two-stage theory to accommodate data it could not have handled otherwise, but it has also raised the question of the necessity or usefulness of the distinction between the two stages. Indeed Tulving (1976) holds that the distinction between recall and recognition has outlived its usefulness. Similarly, Lockhart, Craik and Jacoby (1976) in their concluding comments about the comparison between recognition and recall suggest that "there is little to be gained by attempting to answer such global questions as whether or not recognition involves a search or retrieval phase and whether or not it can be distinguished from recall on this basis. Such questions presuppose a view of memory which is altogether too simple (p.101).

If this latter position is adopted, then a comparison between the effects of noise on recall and recognition does not provide adequate means for investigating the effects of noise on retrieval. Nevertheless it was considered worthwhile to examine possible differential effects of noise upon recognition and recall, since it was suggested in Chapter 2 that a possible reason for some of the discrepancies in the results of studies on the effects of noise upon short-term memory tasks was the type of memory task employed

There are various measures available for assessing recognition including percentage recognition measure (i.e. hits), the d' measure, and the R-measure. Recognition tests themselves are of two types, namely 'forced recognition' and 'unforced recognition', the first being typified by the multiple-choice test. Recognition is forced in the sense that the subject is required to pick out the most plausible from the presented set of items, independently of whether he recognises it in an absolute sense. Such a test is usually called a forced-choice test, but this is misleading since the subject is forced to choose even in yes/no recognition. Yes/no typifies 'unforced recognition' which concerns the degree of plausibility of a given item relative to a criterion for placing it in a certain category, such as the 'yes' category in yes/no recognition. Recall tests can also be divided into forced and unforced and moreover, for some specific recognition tests corresponding recall tests can often be found (Brown, 1976). One such method is the unforced list, which is similar to the yes/no comparison, the only difference being that all the items are presented simultaneously. Accordingly, two methods of analysing the data are to examine the percentage lists and to estimate d' for recognition and for recall. Probably the only published experiment using an unforced list comparison is that of Davis, Sutherland and Judd (1961) who attempted to estimate information transmission in recognition and recall. This unforced list method was adopted by the present study as it was probably the most compatible with the free recall condition of Experiment 2. Since, in Experiment 2, the effect of noise was not significant overall but interacted with the effects of serial position, it was considered desirable to examine the S.P. curves for the recognition task. These have seldom been reported for recognition experiments, although Shiffrin (1970) has reported data where the SP curves for recognition and recall are much the same, although overall recognition performance tended to be better than that of recall. The present experiment was undertaken to investigate the effects of noise on a recognition task and to compare these effects, if any, with those of noise on the immediate free recall condition of Experiment 2. If noise is essentially affecting the encoding and storage components of memory, then recognition and recall performance should be similarly affected by noise.

5.1 Method

5.1.1 Subjects

Twenty undergraduates, 10 males and 10 females aged between 18 and 25 years, participated in the experiment and were paid for their services. Ten subjects, 5 males and 5 females were randomly assigned to each of two groups: Noise (N) and Quiet (Q). Subjects were tested individually.

5.1.2 Apparatus

The 144 slides of 5-letter monosyllabic words drawn from the A or AA frequencies of the Thorndike-Lorge Count which were employed in the previous experiment (see Appendix 2 for full list) comprised the stimuli for this experiment. A further list of 144 common 5-letter monosyllabic words drawn from the same source was also compiled and 12 of these were added to each of the original lists thus making 12 lists of 24 words. The order of the words in each list was then randomly re-arranged (see Appendix 2 for details of lists) and a booklet was made containing one list on each page such that page 1 contained, among others, all the words from the first set of 12 slides to be shown to subject, page 2, all those contained in the second set and so on up to page 12. Pages 13-15 were left blank to avoid possible 'end-spurt' effects.

The slides and the noise conditions were presented as in the previous experiment.

5.1.3 Procedure

The presentation procedure was as described for the immediate recall groups in Experiment 2 with one addition. After the blank slide at the end of the list, subject was instructed to turn to page 1 of the booklet containing the word lists and was informed that the list on page 1 included all the words he had just seen plus some others, in random order and that he was to place a tick by the side of any word which he considered had been presented in the list. After the one minute allowed for recall, the next sequence was started. Once again subjects received 12 lists of 12 words, but they were not informed beforehand of the number of lists to be presented. All subjects received the same lists of words but in ~~the same~~ different orders. As in both previous experiments, the noise was presented at a level of

90dB or 65dB, depending on the experimental condition, during presentation of the stimuli, but at 65dB in both groups during recall. Finally, care was taken to control for possible TOD effects by testing approximately equal numbers of males and females in each group between the hours of 9.00 and 11.00, 11.00 and 13.00 and those of 14.00 and 16.00.

5.2 Results

The analysis of the results falls into four sections: (i) the analysis of the results of Trial 1 only; (ii) the analysis of the results of Trials 3-12; (iii) a comparison between the results of Trial 1 with those of Trials 3-12; (iv) a comparison between the results of the present experiment on recognition memory and those of the previous experiment on recall for a) Trial 1 only and b) Trials 3-12. Performance was assessed by considering the number of words correctly recognised.

The results of Trial 1 only

The mean percentage correct on Trial 1 only was 74.2 in noise and 70.8 in quiet. A 2 x 3 (noise/quiet; serial positions 1-4/5-8/9-12) analysis of variance having a repeated measure on the second factor was carried out on the data. A summary of the results of the analysis is given in Table 23. Only the main effect of serial position reached significance (F=3.98; df 2,36; p .05). Comparisons between means using Tukey's method showed that significantly more words from serial positions 1-4 were recognised than from serial positions 5-8 (q=3.64; df 3,36; p .05). The other comparisons failed to reach significance.

Table 23

Anova 12 Noise x Serial Position for Recognition Scores - Trial 1

Source	SS	df	MS	F
Between subjects	16.07	19		
Noise (N)	0.26	1	0.26	< 1
Subj. w gps.	15.81	18	0.878	
Within subjects	45.33	40		
Serial position (SP)	7.60	2	3.8	3.98*
N x SP	3.34	2	1.67	1.75ns
SP x Subj. w gps.	34.39	36	0.955	

As in the previous experiment the number of intrusion errors was also recorded and for Trial 1 only the mean in noise and that in Q was identical (0.51)

The results of Trials 3-12

The mean percentage correct on Trials 3-12 was 75.5 in noise and 69.7 in quiet. A 2 x 3 (noise/quiet; serial positions 1-4/5-8/9-12) analysis of variance having a repeated measure on the second factor was carried out on the data. A summary of the analysis is given in Table 24 from which it can be seen that only the main effect of serial position reached significance ($F=42.62$; df 2,36; $p < .01$). Comparisons between means using Tukey's method showed that significantly more words were recognised from positions 1-4 than from positions 5-8 ($q=5.82$; df 3,36; $p < .01$). Similarly more words from positions 9-12 were recognised than from positions 5-8 ($q=8.66$; df 3,36; $p < .01$) but the difference between positions 9-12 and 1-4 was not significant. The main effect of noise and the interaction N x SP failed to reach significance.

The mean number of intrusion errors for trials 3-12 was 7.7 in noise and 12.0 in quiet, but this difference failed to reach significance ($U=31.5$; $n_1=10$, $n_2=10$; $p > .50$).

Comparison between Trial 1 and Trials 3-12

Table 25 shows the mean percentage correct for Trial 1 and for Trials 3-12 in noise and quiet. Recognition performance tends to improve from Trial 1 to Trials 3-12 in noise and deteriorate in quiet. The serial position curves for Trial 1 and Trials 3-12 are illustrated in Figure 18.

Table 24

Anova 13 Noise x Serial Position for Recognition Scores (Trials 3-12)

Source	SS	df	MS	F
Between subjects	1,047.23	19		
Noise (N)	81.66	1	81.66	1.52ns
Subj. w gps.	965.57	18	53.64	
Within subjects	1,460.70	40		
Serial position (SP)	733.63	2	366.81	19.43**
N x SP	47.24	2	23.62	1.25ns
SP x Subj. w gps.	679.83	36	18.88	

Table 25

Mean % Correct in Recognition and Recall

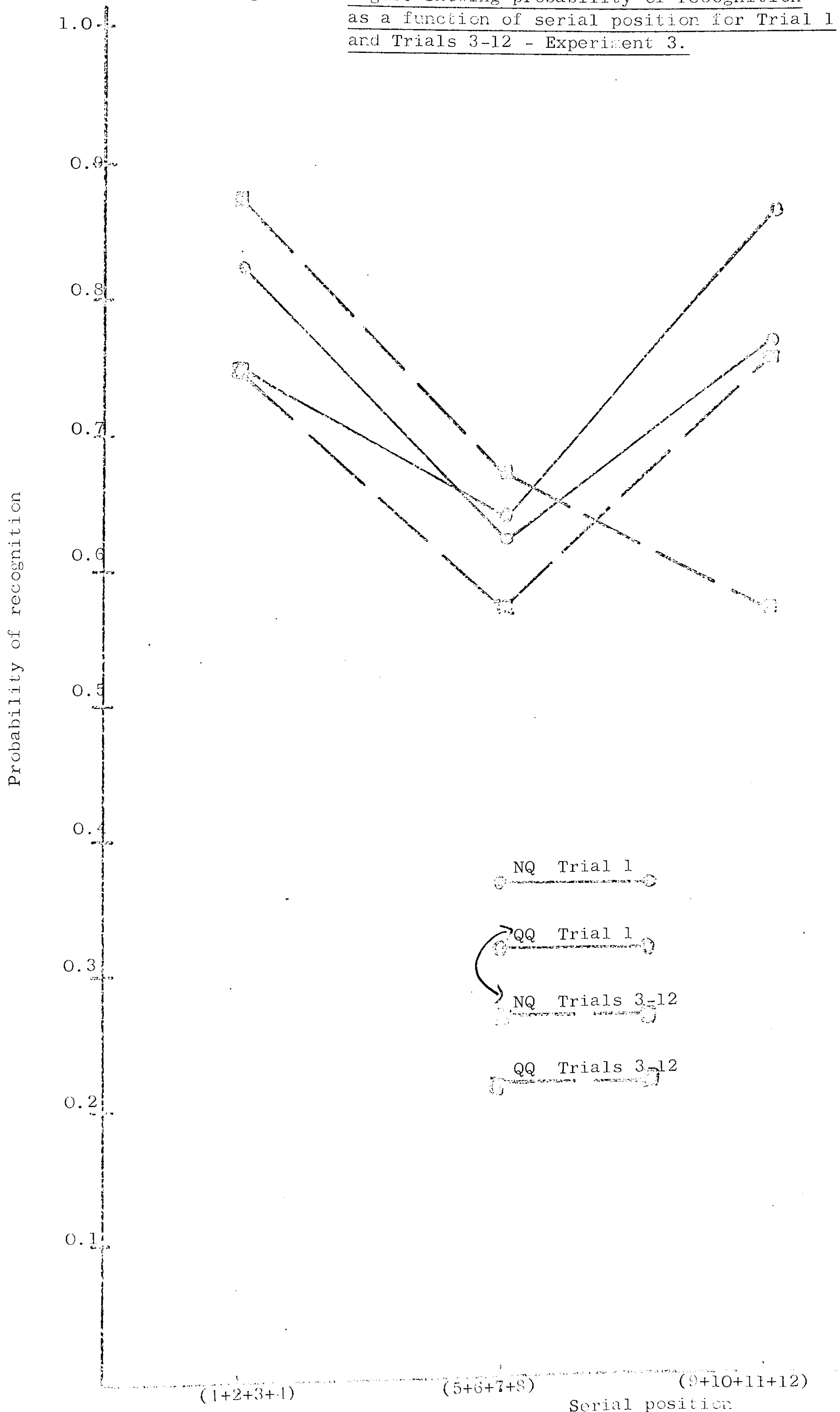
	Trial 1		Trial 3-12	
	N	Q	N	Q
Recognition	74.2	70.8	75.5	69.7
Imm. free recall	55.0	48.3	52.9	50.0

Table 26

Anova 14 Type of Retention x SP x N for Trial 1

Source	SS	df	MS	F
Retention Measure (R)	27.86	1	27.86	38.16**
Noise (N)	1.60	1	1.60	2.19ns
R x N	0.13	1	0.13	<1
Subj. w gps.	41.14	56	0.73	
Serial position (SP)	37.19	2	18.59	18.05**
R x SP	2.53	2	1.26	1.22ns
SP x N	1.33	2	0.66	<1
R x SP x N	3.60	2	1.80	1.75ns
SP x Subj. w gps.	115.26	112	1.03	

Figure 18 Figure showing probability of recognition as a function of serial position for Trial 1 and Trials 3-12 - Experiment 3.



Comparison between recall and recognition

The mean percentage in noise and quiet for recognition and immediate free recall is shown in Table 25. To investigate the possibility of differential effects of N on recall and recognition a 2 x 3 x 2 (recall/recognition; serial position; noise/quiet) unweighted means analysis of variance with repeated measures on the second factor was carried out on the combined data of this experiment and the previous one (immediate free recall condition) for the results of Trial 1 only and for the results of Trials 3-12. A summary of the results of the analysis of the Trial 1 data is presented in Table 26, which reveals a significant main effect of retention measure ($F=38.16$; df 1,56; $p < .01$) recognition performance being superior to recall and serial position ($F=18.05$; df 2,112; $p < .01$). Comparisons between means using Tukeys method (modified for unequal groups) showed that significant words were recognised from positions 1-4 than from positions 5-8 ($q=7.64$; df 3,112; $p < .01$) or from positions 9-12 ($q=6.86$; df 3,112; $p < .01$). The difference between positions 5-8 and 9-12 was not significant. The main effect of noise failed to reach significance as did all the interactions.

The summary table of the results of the analysis of the data from Trials 3-12 is presented in Table 27a which again reveals a significant main effect of retention measure ($F=49.08$; df 1,56; $p < .01$) and of serial position ($F=56.21$; df 2,112; $p < .01$). Comparisons between means using Tukey's method (modified for unequal groups) showed that significantly more words from the final serial positions, 9+10+11+12 were retained than from positions 1+2+3+4 ($q=4.35$; df 3,112; $p < .01$) or from positions 5+6+7+8 ($q=14.55$; df 3,112; $p < .01$) and that more

Table 27 a

Anova 15 Retention measure x Noise x SP (Trials 3-12)

Source	SS	df	MS	F
Retention measure	2,861.02	1	2,861.02	49.08**
Noise	121.30	1	121.30	2.08ns
Retention meas x noise	14.00	1	14.00	<1
Subj. w gps.	3,264.52	56	58.29	
Serial position (SP)	[illegible],830.8[illegible]	2	1,4[illegible].84	58.21**
Retention meas. x SP	83.04	2	41.52	1.65ns
SP x N	176.75	2	88.37	3.51*
Retention meas. x SP x N	7.06	2	3.53	<1
S x Subj. w gps.	2,820.53	112	25.18	

words from positions 1+2+3+4 were retained than from positions 5+6+7+8 ($q=10.20$; df 3,112; $p < .01$). The other main effect, noise, failed to reach significance, as did all the interactions apart from that between SP x N ($F=3.51$; df 2,112; $p < .05$) which was analysed further for simple main effects, following procedure outlined by Kirk (1969) and the summary table for this is given in Table 27b. From Figure 19 it can be seen that performance in Q is better than that in N at SP_1, while the reverse is true at SP_2 and SP_3. However, from the summary table of the simple main effects it can be observed that only the difference between N and Q on SP_3 reaches significance. For comparison purposes the N x SP interaction for Trial 1 only is also shown in diagram

Recall v. recognition performance was also compared using the intrusion error data for Trial 1 only and also for Trials 3-12 and Table 28 shows the mean number of intrusion errors for each condition. A 2 x 2 (noise/quiet; recognition/recall) unweighted means analysis of variance was carried out on these data and the summary table for Trial 1 only is shown in Table 29 and for Trials 3-12 in Table 30. As can be seen from these tables, neither of the main effects was significant in either analysis, although the retention measure approached significance for the second analysis with more intrusion errors during recognition than during recall. The interaction N x RM also failed to reach significance in both analyses.

5.3 Discussion

As in Experiment 2 the effects of N are not significant on Trial 1 although a very slight tendency for performance in N to be better than

Table 27b

Summary Table for Simple Main Effects (SP x N)

Source	SS	df	MS	F
N at SP_1	9.60	1	9.60	< 1
N at SP_2	41.99	1	41.99	1.16
N at SP_3	246.47		246.47	6.80*
Error term		168	36.22	
SP at N	1,702.24	2	851.12	33.8**
SP at Q	1,305.41	2	657.70	26.1**
B x subj. w gps.	2,820.53	112	25.18	

Table 28

Mean Number of Intrusion Errors in Recognition and Recall

	Trial 1		Trials 3-12	
	N	Q	N	Q
Recognition	0.51	0.51	7.7	12.0
Recall	0.35	0.85	7.1	7.45

Figure 19 Figure showing probability of recognition/recall as a function of serial position - to illustrate N x SP interaction for ANOVA 15 - Experiment 3.

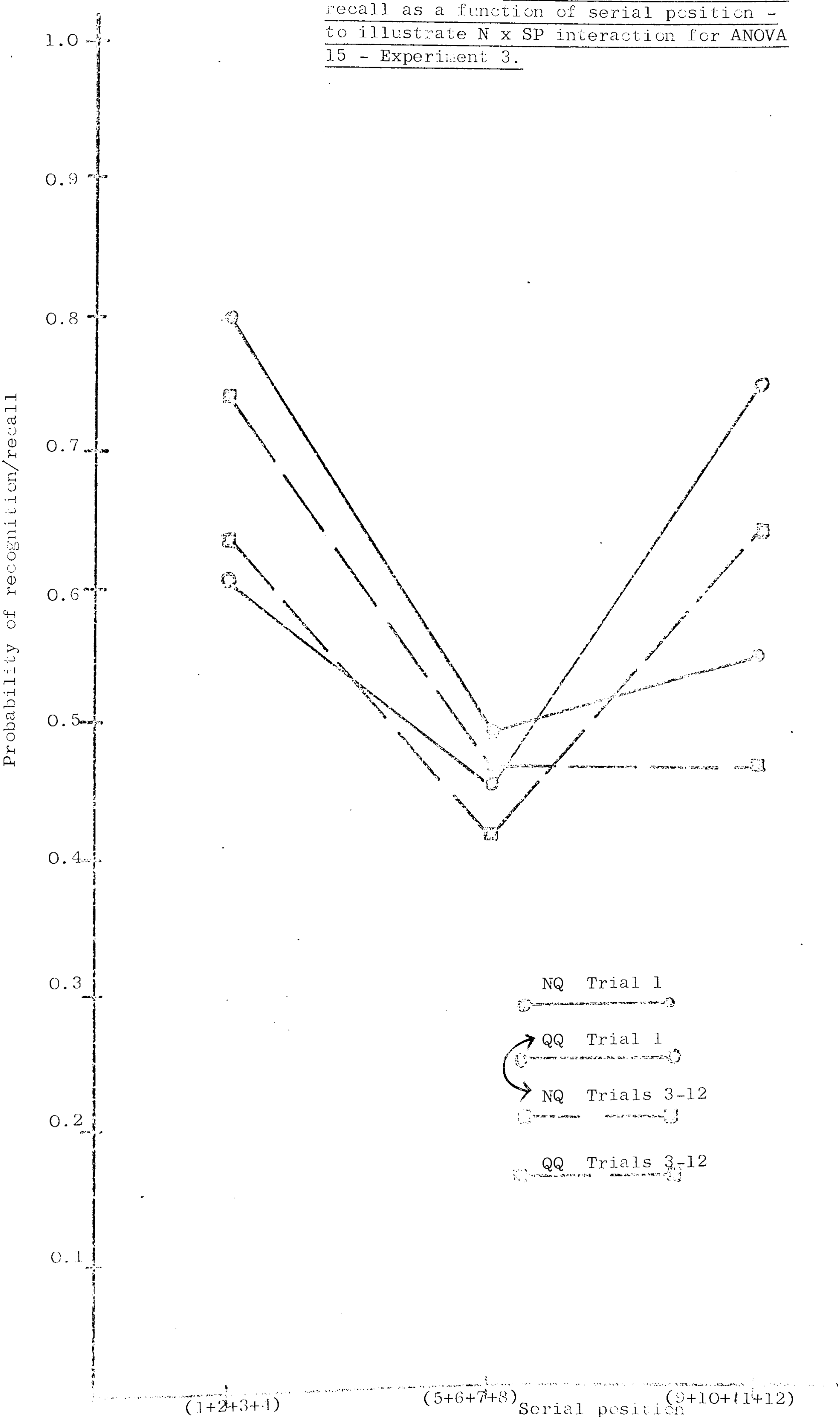


Table 29

Anova 16 N x Retention Measure for Intrusion Errors (Trial 1)

Source	SS	df	MS	F
Noise (N)	0.80	1	0.80	< 1
Retention Measure (RM)	1.20	1	1.20	1.38ns
N x RM	0.80	1	0.80	< 1
Within cell	48.90	56	0.87	

Table 30

Anova 17 Noise x Retention Measure for Intrusion Errors (Trials 3-12)

Source	SS	df	MS	F
Noise (N)	72.11	1	72.11	2.65ns
Retention Measure (RM)	88.38	1	88.38	3.25+
N x RM	51.99	1	51.99	1.91ns
Within cell	1,522.85	56	27.19	

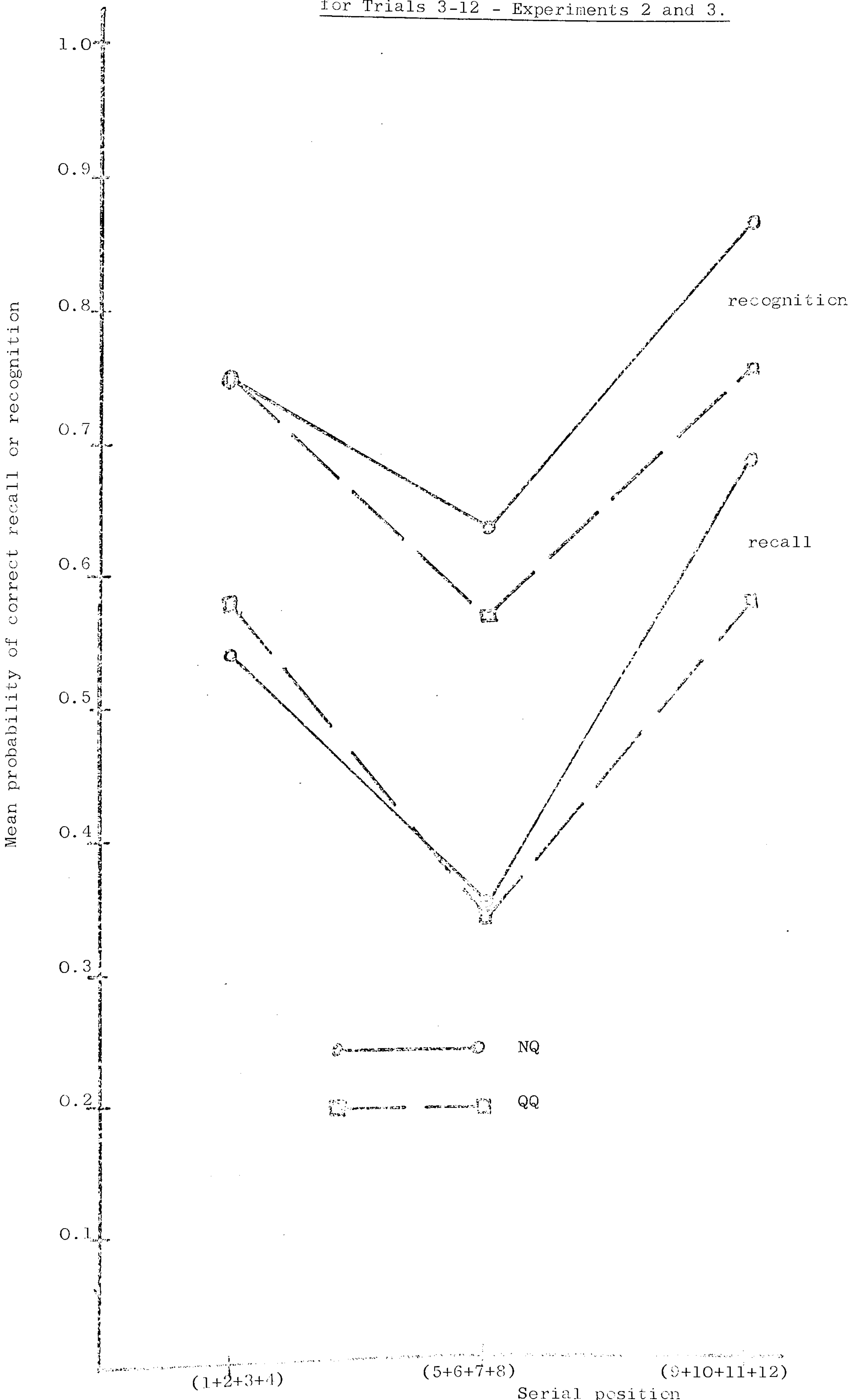
that in Q was obtained. The mean percentage recognised in N was 74.3 while in Q it was 70.8. The N x SP interaction also failed to reach significance for Trial 1, although a similar graph to that for free recall Trial 1 in Experiment 2 was obtained. The comparison between performance on Trial 1 and that on Trials 3-12 also reveals a similar result to that of Experiment 2 with greater primacy, but less recency on Trial 1 compared with Trials 3-12 (see Figure 19).

The results of the analysis for Trials 3-12 suggest that noise has a slightly beneficial (but not significant) effect on the number of words retained, the mean percentage recognised being 75.5 in N and 69.7 in Q. This is similar to the effects of noise on recall, which also showed a small improvement in performance in N. This finding of a slight beneficial effect of N for recognition performance is in the same direction as that found by previous work (Archer and Margolin, 1970; Wesner, 1972). Archer and Margolin presented their subjects with a list of 2-digit numbers, each number being followed by a 'remember' or a 'don't remember' instruction. White noise was associated with some of the items. In an immediate recognition test there was a highly significant tendency for more numbers associated with N than with no N to be correctly recognised, at least for items associated with the 'remember' instructions. Wesner presented institutionalised mongoloid retardates and normal kindergarten children with pictures of twenty common objects and an appropriate name for each. He found that verbal items accompanied by white noise were better recognised immediately after training by both groups of subjects. Taken together the results suggest that noise tends to affect recognition performance by improving it. However, in the analysis of Trials 3-12, the N x SP interaction failed to reach significance, although from Figure 20 it can be seen that performance in N tends to be better than that in Q on later serial positions (as in the free recall condition of Experiment 2), while performance in Q is no better than that in N on serial positions 1-4, whereas in the free recall of Experiment 2, there was a tendency for performance in Q to be better on early serial positions.

This lack of a significant interaction between N and SP in the case of recognition whereas one was obtained for free recall, would possibly suggest that in the recall situation N was affecting a component of memory which is not involved in recognition. Although this seems unlikely since similar graphs (see Figure 20) of N x SP are obtained for each retention measure despite the fact that the interaction did not reach significance in the case of recognition, it was considered worthwhile to compare the results of recognition and recall statistically (see Results section for details of the analyses). If N differentially affects the two types of retention measure, then a significant interaction between N and RM would be expected. As can be seen from Tables 26 and 27a, in neither the analysis for Trial 1 data nor that for Trials 3-12 was there any evidence of a differential effect of noise on recognition and recall. The results of the present experiment would therefore seem to support the suggestion that noise exerts its influence on the encoding stage of short-term memory and the observed tendency for performance to be better in noise on later serial positions also supports the suggestion that noise facilitates phonemic coding.

If a modified theory of recognition memory is adopted (Anderson and Bower, 1974; Kintsch, 1974) in which retrieval is deemed to play a

Figure 20 Figure showing the probability of recall or recognition as a function of serial position for Trials 3-12 - Experiments 2 and 3.



part in recognition as well as in recall, then the present experiment does not rule out the possibility that noise affects retrieval as suggested by Schwartz (according to Murdock, 1974) since the noise was only present during the presentation of items and it would thus seem desirable to examine the effects of noise during the recall of the items as well as during their presentation in order to obtain a clearer picture.

CHAPTER 6

THE EFFECTS OF NOISE PRESENTED AT DIFFERENT POINTS DURING THE TASK

Although the previous experiment suggests that N effects occur during the process of encoding and storage, it does not eliminate the possibility proposed by Schwartz (cited by Eysenck, 1976) and Eysenck (1974, 1976) that N affects retrieval, since recognition memory is generally now deemed to involve retrieval processes (Tulving, 1976). Some common observations also indicate that arousal may affect the ease of retrieval. For example, one is sometimes unable to retrieve some desired item of information when highly motivated to do so, followed by recall soon after abandoning the attempt (James, 1890). Additionally, there appear to be frequent retrieval failures under examination stress. Pascal (1949) found that brief relaxation instructions given immediately prior to recall significantly improved recall performance. Bourne (1955) found that short-term recall of paired-associates was facilitated by experimentally induced tension at test. White noise was introduced by Uchling and Sprinkle (1968) just prior to recall and they found that it facilitated recall after 24 hours or one week, but had no effect on an 'immediate' recall test 3 minutes after learning trials. However, Berlyne et al. (1965) found no effect of relatively low levels of WN at the time of a test trial 24 hours after p-a learning. Similarly Sloboda and Smith (1968) found that bursts of WN during a 2 second or 12 second retention interval between presentation and recall had no effect on recall. Thus while relatively few studies have concentrated on the effects of arousal just prior to, or during recall, it appears that such effects are a possibility and therefore worthy of further examination. The present experiment was thus designed to investigate the effects of WN during presentation and/or recall upon immediate recall performance.

In the previous experiments, although a subject was required to place an item in the box on the response sheet corresponding to its serial position at presentation, he was free to record his responses in any order, i.e. he could write down the last few words in a list first. Even though no record was kept of subjects output order it was observed that generally he did place the terminal list items in their respective boxes before attempting to recall words from earlier SP's, as would be expected from the results of Deese and Kaufman (1957). However, the possibility remains that the observed differences between the SP curves in N and Q, showing better performance in N on the recency part of the curve and slightly worse performance on the primacy area, which was attributed to increased emphasis on phonemic coding in N may have been due to differing orders of recall in the two conditions. Laughery and Bergman (1970) obtained a similar cross-over effect of SP curves for two methods of recall - serial recall, in which subjects have to record items in the order they were presented and ordered recall, which was the same as the ordered recall in Experiments 1 and 2. Performance using ordered recall was superior to serial recall in the recency portion of the curve, while the reverse tended to be the case in the early part of the list. The superiority of ordered recall in the final list positions was attributed to the fact that in this condition subjects had recalled the items in a different order. Thus, there remains the possibility in Experiment 2 that the different SP curves for N and Q for ordered recall may have been due to the fact that more subjects adopted the strategy of writing down the last few items first in N than they did in Q. It was thus considered necessary to take note of subjects response strategy. If the observed serial position effects were due to differences in the order of report, then more responses recorded in the order 1-9 (i.e.

serial recall) would be expected in Q than in N, since ordered recall is worse than serial recall on the latter serial positions and this is where performance in Q is worse than that in N. Another reason for taking note of output order in this experiment was that the possible effects of N upon retrieval were to be examined and N during recall might also affect the output order of the subjects. Further, since the beneficial effects of N on recall appeared to be greater when order information as well as item information was required, a tendency also noted by Hockey and Hamilton (1970) a different type of stimulus material was employed in the present study. Nine digit sequences instead of words were used and as all the digits 1 - 9 were used in each of the sequences, the recall test was purely one of the retention of order information.

6.1 Method

6.1.1 Subjects

Sixty sixth-formers, 30 males and 30 females, aged between 16 and 18 years served as subjects and were paid for their services. Subjects were randomly allocated to one of four experimental conditions: noise during presentation of stimuli and recall (NN); noise during presentation of stimuli but not during recall (NQ); quiet during presentation and noise during recall (QN); quiet during presentation and recall (QQ). Twenty subjects, 10 males and 10 females, were assigned to both the NN and QQ conditions and 10 subjects, 5 males and 5 females, were assigned to both the NQ and QN conditions. The subjects were tested individually.

A list of 60 9-digit sequences was compiled using random number tables with the restriction that no digit could appear more than once in a particular sequence or in the same serial position for two successive sequences; zero was not used. The digits were punched on to paper-tape in Binary Coded Decimal with 30 spaces between each sequence.

The Binary Coded punched tape was fed into an Elliot photo-electric tape reader, the data output of which was fed into a binary to decimal convertor and presented on a Mallard Numerical Inaccatior ZM1020. Immediately above the nixie tube was fitted a small light which acted as a warning signal.

The same noise tape as in the previous experiments was used and once again it was played on a Ferrograph tape-recorder. However, because of the unavailability of a speaker, the noise was presented to subjects over headphones. The volume control of the tape-recorder was adjusted until the noise level at the midpoint of the headphone was either 90dB or 65dB. Since Hartley and Carpenter (1974) found no significant difference between free-field noise and head-phone noise in their effects on the number of corrects, gaps and errors in a serial reaction task it was assumed that the effect of the difference in the method of noise presentation between this experiment and the three previous ones would be minimal.

6.1.2 Procedure

The subject was seated at a table in such a position that the nixie tube was easily seen. He was instructed that when the light above the nixie tube was extinguished he would be shown a sequence of 9-digits, one at a time. When the light reappeared (for 2 secs.) at the end of the sequence he was to write down the digits on specially prepared response sheets containing rows of 9 boxes. The subject was required to put each digit in the sequence in the box corresponding to its position in the list. If the subject was unsure of a response he must guess rather than leave any of the 9 boxes blank. This was done because in a small pilot study some subjects adopted the strategy of attempting to learn only the first 6 digits and leaving the last 3 boxes blank every trial. As in the previous experiments, the subject was free to fill in the boxes in any order, but notice was to be taken of his order of recall, although the subject was not informed of this. Carbon paper was attached to the response sheet which was placed over a box containing a roll of slowly moving paper. In the box was a window and the subject was required to write above this so that his responses would be copied on to the moving paper, from which the subject's order of recall could be observed.

After the experimenter had ensured that the instructions had been understood, the experiment began. Each digit was presented for $\frac{1}{2}$ second and so the total presentation time for each sequence was $4\frac{1}{2}$ seconds. The subject was allowed 15 seconds to complete his recall, but after 13 seconds of this period, the warning light came on for 2 seconds to indicate to the subject that the next sequence was about to start.

Altogether subjects received 55 sequences of 9-digits. Subjects in the NN group received noise at a level of 90dB throughout the experiment and those in the QQ group, at a level of 65dB. However, subjects in the NQ group received noise at a level of 90dB during the presentation of the digits and at a level of 65dB during recall, while subjects in the QN group received these conditions in reverse order.

As in the previous experiments care was taken to control for possible TOD effects. In each experimental condition approximately equal numbers of males and females were tested between the hours of 09.00 and 11.00, 11.00 and 13.00 and those of 14.00 and 16.00.

6.2 Results

Subjects were given 5 practice trials before the main block of 50 trials, and although the main analyses were carried out on the data from these latter trials, for comparison purposes, the data from the very first trial given to the subjects were also analysed. Thus the analysis of the results is divided into two sections: (i) the analysis of the results of Trial 1 only and (ii) the analysis of the results of Trials 6-55. In both, the analysis is undertaken by step-wise comparisons between two N conditions at a time. However, results of analyses involving all four N conditions are given in the Appendix.

(i) Results of Trial 1 only

Recall performance was assessed by considering the total number of digits recorded in their correct serial position, and Table 31 shows

Table 31

% Correct on Trial 1 in each N condition

NN	NQ	QN	QQ
55.5	40	52.2	35.5

% Correct on Trials 6-55

NN	NQ	QN	QQ
63	58.9	72.2	57.3

% Written down order 1-9

NN	NQ	QN	QQ
70.4	61.8	58.4	40.4

the mean percentage correct in each N condition. Separate 2x3 (noise condition; Serial positions 1-3; 4-6; 7-9) analyses of variance having a repeated measure on the second factor were computed for 2 N conditions at a time and the summary tables for these are shown in Table 32.

NQ v. QQ comparison

Only the main effect of serial position reached significance ($F=4.77$; df 2,56; $p < .05$) and the comparisons between means for this main effect using Tukey's method showed that significantly more digits were recalled from serial positions 1-3 than from positions 4-6 ($q=4.33$; df 3,56; $p < .05$). The other comparisons failed to reach significance.

QN v. QQ comparison

The main effect of serial position reached significance ($F=13.76$; df 2,56; $p < .01$) and comparisons between means using Tukey's method revealed that significantly more words were recalled from positions 1-3 than from positions 4-6 ($q=5.33$; df 3,56; $p < .01$) and from positions 7-9 ($q=7.33$; df 3,56; $p < .01$).

NN v. QN comparison

Once again the main effect of serial position reached significance ($F=12.61$; df 2,56; $p < .01$) and comparisons between means using Tukey's method revealed that significantly more digits were recalled from positions 1-3 than from positions 4-6 ($q=4.29$; df 3,56; $p < .05$) or from positions 7-9 (qx6.94; df 3,56; $p < .01$).

Table 32

Anova - N x Serial position (Trial 1)

(1) NQ v. QQ

Source	SS	df	MS	F
Noise (N)	0.27	1	0.27	< 1
Subj. w gps.	83.2	28	2.97	
Serial position (SP)	5.73	2	2.86	4.77*
N x SP	1.87	2	0.93	1.55
SP x Subj. w gps.	33.40	56	0.60	

(2) QN v. QQ

Source	SS	df	MS	F
Noise (N)	4.93	1	4.93	1.69
Subj. w gps.	81.77	28	2.92	
Serial position (SP)	17.06	2	8.53	13.76**
N x SP	1.87	2	0.93	1.5
SP x Subj. w gps.	34.93	56	0.62	

(3) NN v. QN

Source	SS	df	MS	F
N	0.13	1	0.13	<1
Subj. w gps.	94.04	28	3.38	
SP	18.66	2	9.33	12.61**
N x SP	0.87	2	0.43	<1
SP x Subj. w gps.	41.36	56	0.74	

(4) NN v. NQ

Source	SS	df	MS	F
N	4.30	1	4.30	1.26
Subj. w gps.	95.47	28	3.41	
SP	5.37	2	2.68	4.00*
N x SP	2.82	2	1.41	2.10
SP x Subj. w gps.	37.83	56	0.67	

(5) NN v. QQ

Source	SS	df	MS	F
Between subjects	126.54			
N	10.81	1	10.81	3.55+
Subj. w gps.	115.73	38	3.04	
Within subjects	73.33			
SP	17.51	2	8.75	12.01**
N x SP	0.45	2	0.22	<1
SP x Subj. w gps.	55.37	76	0.728	

NN v. NQ comparison

The main effect of serial position once again reached significance ($F=4.00$; df 2,56; $p < .05$) and comparisons between means using Tukey's method revealed that significantly more digits were recalled from positions 1-3 than from positions 4-6, ($q=3.62$; df 3,56; $p < .05$). The other comparisons failed to reach significance.

NN v. QQ comparison

As with the other comparisons, the main effect of serial position reached significance ($F=12.01$; df 2,76; $p < .01$) and comparisons between means using Tukey's method revealed that significantly more digits were recalled from positions 1-3 than from positions 4-6 ($q=5.61$- df 3,76; $p < .01$) or from positions 7-9 ($q=6.77$; df 3,76; $p < .01$). The main effect of noise approached significance ($F=3.55$; df 1,38; $p < .10$) with performance in the NN condition being better than that in QQ.

(ii) Results of trials 6-55

Once again recall performance was assessed by considering the total number of digits recorded in the correct serial position and the mean percentage correct in each N condition can be seen in Table 31 as can also the mean percentage written down in the order 1-9. Separate 2x5 (N condition; Blocks of 10 trials) analyses of variance having a repeated measure on the second factor were carried out on the number written down order 1-9 for two N conditions at a time and the summary tables for these are shown in Table 33 , from which it can be seen that all the main effects apart from one failed to reach significance, as

Table 33

Anova - Noise x Blocks (number order 1-9)

(1) NQ v. QQ

Source	SS	df	MS	F
Noise (N)	158.37	1	158.37	2.78
Subj. w gps.	1,595.62	28	56.99	
Blocks (B)	10.40	4	2.60	< 1
N x B	2.00	4	0.50	< 1
B x Subj. w gps.	318.38	112	2.84	

(2) QN v. QQ

Source	SS	df	MS	F
N	105.57	1	105.57	2.03
Subj. w gps.	1,457.22	28	52.04	
B	4.80	4	1.20	< 1
N x B	3.86	4	0.96	< 1
B x Subj. w gps.	370.38	112	3.31	

Table 33 cont.

(3) NN v. QN

Source	SS	df	MS	F
N	48.65	1	48.65	< 1
Subj. w gps.	1,462.29	28	52.22	
B	15.06	4	3.76	1.08
N x B	3.86	4	0.96	< 1
B x Subj. w gps.	389.26	112	3.47	

(4) NN v. NQ

Source	SS	df	MS	F
N	21.73	1	21.73	< 1
Subj. w gps.	1,600.69	28	57.17	
B	15.06	4	3.76	1.25
N x B	7.60	4	1.90	< 1
B x Subj. w gps.	337.26	112	3.01	

(5) NN v. QQ

Source	SS	df	MS	F
Between subjects	2,234.96			
N	447.01	1	447.01	9.50**
Subj. w gps.	1,787.95	38	47.07	
Within subjects	526.80			
B	14.08	4	3.52	1.07
N x B	13.32	4	3.33	1.01
B x Subj. w gps.	499.40	152	3.28	

did all the interactions. Significantly more lists of digits were written down in the order 1-9 in the NN condition than in QQ ($F=9.50$; df 1,38; $p < .01$). Separate 2x5x3 (N condition; Blocks of 10 trials; serial positions 1-3; 4-6; 7-9) analyses of various having repeated measures on the second and third factors were carried out on the number of digits correct for two N conditions at a time and the summary tables for these are given in Table 34a.

NQ v. QQ comparison

The main effects of blocks ($F=3.68$; df 4,112; $p < .01$) and serial position ($F=5.95$; df 2,56; $p < .01$) reached significance. Comparisons between means for the main effect of blocks using Tukey's method revealed that significantly more digits were recalled in Trials 46-55 than in Trials 6-15 ($q=4.61$; df 5,112; $p < .05$). All other comparisons failed to reach significance. Comparisons between means for the main effect of serial position revealed that significantly more digits were recalled from positions 1-3 than from positions 4-6 ($q=4.61$; df 3,56; $p < .01$) or from positions 7-9 ($q=3.74$; df 3,56; $p < .05$).

QN v. QQ comparison

This comparison revealed a significant main effect of N ($F=7.05$; df 1,28; $p < .01$) performance in the QN being better than that in QQ and serial position ($F=6.98$; df 2,56; $p < .01$). Comparisons between means using Tukey's method revealed that significantly more digits were recalled from serial positions 1-3 than from positions 4-6 ($q=4.52$; df 3,56; $p < .01$) or from positions 7-9 ($q=4.63$; df 3,56; $p < .01$).

Table 34 a

Anova - Noise x Blocks x Serial position

(1) NQ v. QQ

Source	SS	df	MS	F
Noise (N)	16.79	1	16.79	< 1
Subj. w gps.	6,243.76	28	222.99	
Blocks (B)	314.99	4	78.75	3.68^{**}
N x B	57.72	4	14.43	< 1
B x Subj. w gps.	2,393.11	112	21.37	
Serial position (SP)	1,329.27	2	664.63	5.95^{**}
N x SP	273.26	2	136.63	1.22
SP x Subj. w gps.	6,256.35	56	111.72	
B x SP	45.59	8	5.70	< 1
N x B x SP	43.05	8	5.38	< 1
B x SP x Subj. w gps.	2,326.73	224	10.39	

(2) QN v. QQ

Source	SS	df	MS	F
N	1,926.72	1	1,926.72	7.05**
Subj. w gps.	7,654.86	28	273.39	
B	139.70	4	34.92	1.68
N x B	139.83	4	34.96	1.68
B x Subj. w gps.	2,327.64	112	20.78	
SP	1,256.88	2	628.44	6.98**
N x SP	162.76	2	81.38	< 1
SP x Subj. w gps.	5,041.55	56	90.03	
B x SP	68.25	8	8.53	< 1
N x B x SP	64.78	8	8.10	< 1
B x SP x Subj. w gps.	2,158.80	224	9.64	

(3) NN v. QN

Source	SS	df	MS	F
N	739.68	1	739.68	1.99
Subj. w gps.	10,425.55	28	372.34	
B	234.21	4	58.55	3.70**
N x B	157.29	4	39.32	2.49*
B x Subj. w gps.	1,771.39	112	15.81	
SP	1,401.12	2	700.56	9.97**
N x SP	249.54	2	124.77	1.78
SP x Subj. w gps.	3,933.45	56	70.24	
B x SP	58.25	8	7.28	< 1
N x B x SP	58.12	8	7.26	< 1
B x SP x Subj. w gps.	2,013.31	224	8.99	

(4) NN v. NQ

Source	SS	df	MS	F
N	158.63	1	158,63	< 1
Subj. w gps.	9,014.45	28	321.94	
B	464.02	4	116.00	7.07**
N x B	20.53	4	5.13	< 1
B x Subj. w gps.	1,836.86	112	16.40	
SP	1,426.84	2	713.42	7.76**
N x SP	406.70	2	203.35	2.21
SP x Subj w gps.	5,148.25	56	91.93	
B x SP	58.65	8	7.33	< 1
N x B x SP	13.46	8	1.68	< 1
B x SP x Subj. w gps.	2,181.24	224	9.74	

(5) NN v. QQ

Source	SS	df	MS	F
Between subjects	12,722.61	39		
N	418.34	1	418.34	1.29
Subj. w gps.	12,304.27	38	323.80	
Within subjects	16,020.00	560		
B	498.33	4	124.58	6.20**
N x B	103.35	4	25.84	1.29
B x Subj. w gps.	3,052.95	152	20.08	
SP	3,729.17	2	1,864.58	26.72**
N x SP	21.20	2	10.54	< 1
SP x Subj. w gps.	5,303.74	76	69.79	
B x SP	111.58	8	13.95	1.33
N x B x SP	20.40	8	2.55	< 1
B x SP x Subj. w gps.	3,179.39	304	10.46	

NN v. QN comparison

In this comparison significant main effects of blocks (F=3.70; df 4,112; p < .01) and serial position (F=9.97; df 2,56; p < .01) were observed. Comparisons between means for the main effect of blocks revealed that significantly fewer digits were recalled in Trials 6-15 than in Trials 26-35 (q=4.36; df 5,112; p < .05), Trials 36-45 (q=4.84; df 5,112; p < .01) or in Trials 46-55 (q=4.18; df 5,112; p < .05). Other comparisons failed to reach significance. Comparisons between means for the main effect of serial position using Tukey's method revealed that significantly more digits were recalled from positions 1-3 than from positions 4-6 (q=5.14; df 3,56; p < .01) or from positions 7-9 (qa5.82; df 3,56; p < .01). The first order interaction Noise x Blocks also reached significance (F= 2.49; df 4,112; p < .05) and this was analysed further for simple main effects following the procedure outlined by Kirk (1969) and the summary table for this is given in Table 34 b, from which it can be seen that the effects of the different N conditions are only significantly different for Trials 26-35 with performance under the QN condition being better than that in NN.

NN v. NQ comparison

Once again the main effects of blocks (F27.07; df 4,112; p < .01) and serial position (F-7.76; df 2,56; p < .01) reached significance. Comparisons between means for the main effect of blocks revealed that significantly fewer digits were recalled from Trials 6-15 than from Trials 36-45 (q=5.23; df 5,112; p < .01) or from Trials 46-55 (q=6.71; df 5,112; p < .01). All other comparisons failed to reach significance. Comparisons between means for the main effect of serial

Table 34b

Simple Main Effects N x Blocks

NN v. QN

Source	SS	df	MS	F
N at b_1	233.41	1	233.41	2.68
N at b_2	215.55	1	215.55	2.47
N at b_3	361.16	1	361.16	4.14*
N at b_4	77.45	1	77.45	<1
N at b_5	9.34	1	9.34	<1
Error		140	87.12	
Blocks at NN	256.47	4	64.12	4.05**
Blocks at QN	134.90	4	33.72	2.13+
Error		112	15.81	

position using Tukey's method showed that significantly more digits were recalled from positions 1-3 than from positions 4-6 (q=5.05; df 3,56; $p < .01$) or from positions 7-9 (q=4.57; df 3,56; $p < .01$).

NN v. QQ comparison

Once again the main effects of blocks (F=6.20; df 4,152; $p < .01$) and serial position (F-26.72; df 2,76; $p < .01$) reached significane. Comparisons between means for the main effect of blocks revealed that significantly more digits were recalled from Trials 36-45 than from Trials 6-15 (q=5.01; df 5,152; $p < .01$) or from Trials 16-25 (q=3.94; df 5,152; $p < .05$). Significantly more digits were also recalled from Trials 46-55 than from Trials 6-15 (q=5.80; df 5,152; $p < .01$) or from Trials 16-25 (q=4.72; df 5,152; $p < .05$). Comparisons between means for the main effect of serial position using Tukey's method revealed that significantly more digits were recalled from positions 1-3 than from positions 4-6 (q=8.06; df 3,76; $p < .01$) or from positions 7-9 (q=9.89; df 3,76; $p < .01$).

Spearman rank correlation coefficients were also computed for the total number of digits correct x number written down in the order 1-9 for each noise condition and these are shown in Table 35 , for which it can be seen that only the coefficient for the QQ condition reached significance ($r_s = -0.75$).

Table 35

Spearman Rank Correlation Coefficient for Total Number of Digits Correct x Number Written Down Order 1-9

	NN	NQ	QN	QQ
r_s =	0.17	-0.25	0.12	-0.75*
	(n=20)	(n=10)	(n=10)	(n=20)

6.3 Discussion

The analysis of the results of noise at input only compared with quiet throughout are very similar to the ordered recall results of Experiments 1 and 2. N during input tends to improve performance, but not significantly so. The N x SP interaction did not reach significance for either analysis although from Figures 21 and 22 it can be seen that similar SP curves to those for the previous experiments were obtained, with N tending to improve performance during the recency portion of the curve but causing a slight deterioration on early positions. Since it was suggested in the introduction that these differences in the serial position curve may be due to the order in which subjects wrote down their responses, the present experiment recorded this information. From Table 31 it can be seen that in NQ, 61.8% of the responses were written down serially (i.e. order 1-9), whereas in QQ only 40.4% were recorded in this order. However, this difference between the two conditions, though quite sizeable was not significant. Nevertheless, if, as Laughery and Bergman (1970) suggest, order of recall affects the SP curve with 'ordered' recall resulting in better recency than serial recall then one would expect from the above data that performance would be better in QQ in the recency part of the curve since fewer responses are recalled serially in this condition. In fact, the opposite occurs and therefore it would seem that the order of recall is not a satisfactory explanation for the observed serial position curves.

The analysis of the QN v. QQ conditions revealed a significant beneficial effect of N during recall. However, in the NN condition and the NQ

Figure 21 Figure showing the probability of recall as a function of serial position for Trial 1 - Experiment 4.

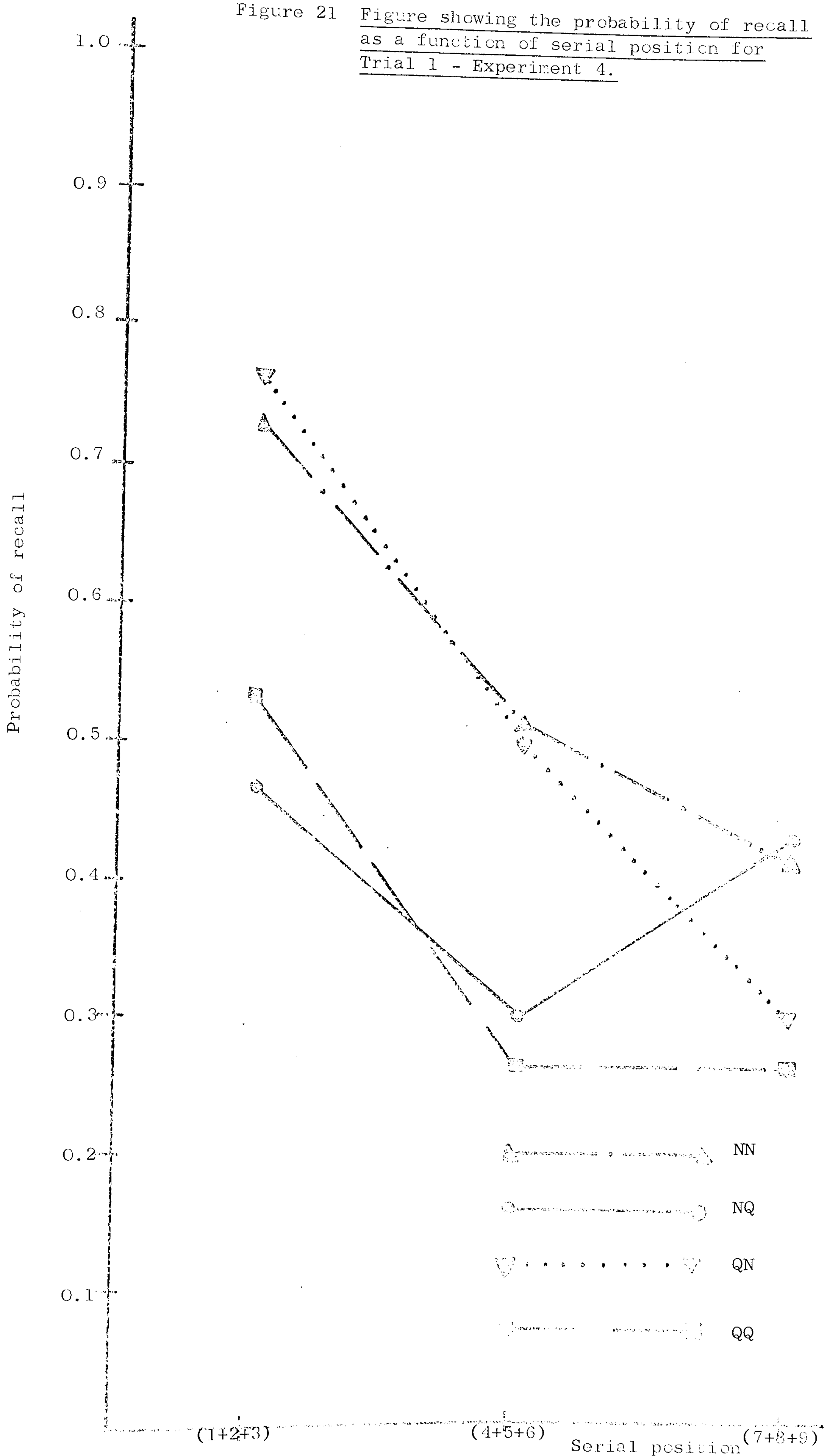
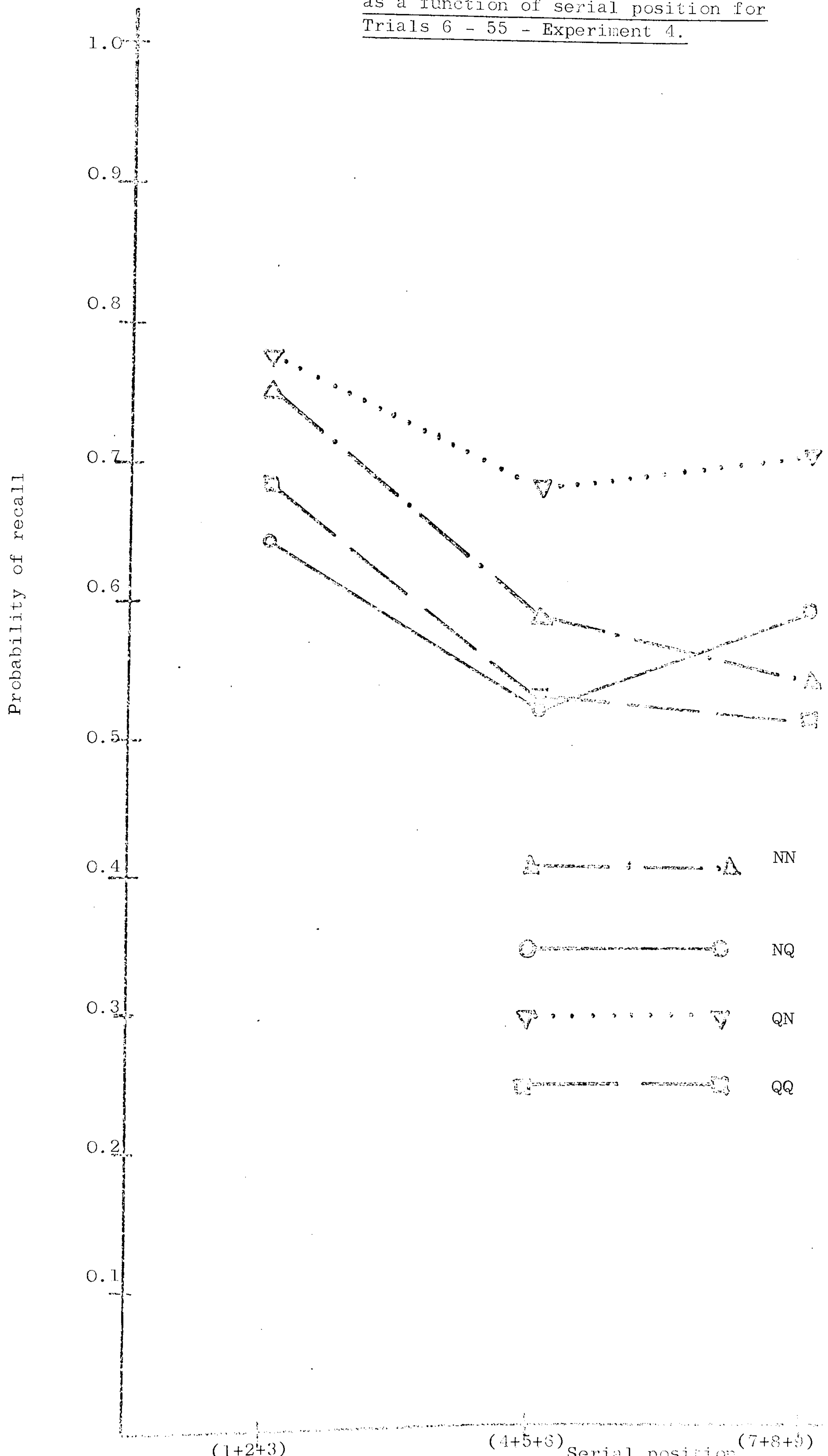


Figure 22 Figure showing the probability of recall as a function of serial position for Trials 6 - 55 - Experiment 4.



condition, performance tended to be better than that in QQ, but not significantly so. Thus the results of the present experiment suggest that N affects retrieval and that the beneficial effects of noise during presentation and those during recall are not additive.

A point made by Tulving and Thomson (1973) is that retrieval, properly understood, involves an interaction between coding processes and test conditions. For example, whether or not recall is facilitated by the presence of certain 'retrieval cues' may depend critically on the form of the items initial encoding, and a failure to recall might just as well be viewed as a consequence of inappropriate initial coding as due to an inadequate retrieval cue (Tulving and Thomson, 1973). Work by Eagle and Leiter (1964) and Jacoby (1973) also suggests that different encoding operations are optimal for different retrieval conditions. Lockhart, Craik and Jacoby (1976) propose that the memory system has two modes of retrieval able. The first of these may be described as a process of reconstruction and the second as a search or scanning operation in which recent episodic traces are examined for the pre-serve of some salient feature. In their earlier paper, Craik and Lockhart (1972) argued that deeper semantic processing yielded a more 'durable' code. However, a more recent view (Lockhart et al, 1976) proposes that all encoded events are equally durable - traces are not lost from the system - but that some traces become impossible to access because they are not distinctive, but similar to many other events. Thus only very recent events of this type can be retrieved, and they are accessed by means of the scanning operation. Events which are encoded in a richer semantic fashion may be accessed by either retrieval mode. If a subject chooses to locate an item by scanning, semantic information will not yield superior performance, or evidence of a more durable trace, since semantic distinctiveness in this surface sense is not a better basis for discrimination than phonemic or structural distinctiveness, but if a subject chooses the reconstruction strategy, semantic information will be superior since the encoded event is more distinctive and the episodic trace can be contacted more readily by semantic retrieval information. This proposal thus leads to the prediction that if an event is encoded semantically, it may or may not yield superior performance, depending on the retrieval mode used and evidence for this is provided in the studies of Jacoby (1974).

The results of the present experiment would fit in well with the proposal of two retrieval strategies which are associated with different optimal encoding operations. However, before discussing the results further, it was decided to examine the effects of N during retrieval on the immediate recall of the lists of 12 words which had been used in Experiment 2. Since the present experiment was concerned with order information only there was the possibility that N during recall, while it exerted effects on the retrieval of order information, may not result in similar effects for item information because it has been noted by Estes (1972), among others, that in certain cases item and order information display different relationships with experimental operations e.g. the retention interval (Bjork and Healy, 1974) and grouping (Wickelgren, 1967).

6.4 Method

6.4.1 Subjects

Twenty undergraduates, 10 males and 10 females, aged between 18 and 25 years, participated in the experiment and were paid for their services 10 subjects, 5 males and 5 females, were randomly assigned to each group: noise during both presentation of the stimuli and during recall (NN) or quiet during presentation of the stimuli but noise during recall (QN). The subjects were tested individually.

6.4.2 Apparatus

The apparatus employed was as specified for Experiment 2.

6.4.3 Procedure

The presentation and recall procedure was as described for the immediate recall condition of Experiment 2 with the exception that noise at 90dB was presented during the presentation of the stimuli and during recall in the NN group, while in the QN group the noise level was at 65dB during stimulus presentation but at 90dB during recall.

As before, care was taken to control for possible TOD effects.

6.5 Results

Recall performance was assessed in two ways: (a) by considering the number of words recalled in the correct serial position (ordered recall) and (b) by considering the number of words recalled irrespective of position (free recall). The analysis of the results is divided into two sections: (i) the analysis of the results of Trial 1 only and (ii) the analysis of the results of Trials 3-12. In both the analysis is undertaken by step-wise comparisons between two noise conditions at a time. However, results of analyses involving all four N conditions are given in Appendix 4.

(i) Results of Trial 1 only

The mean percentage correct in each N condition for both ordered and free recall is shown in Table 36.

Separate 2x3 (Noise condition; serial positions 1-4; 5-8; 9-12) analyses of variance having a repeated measure on the second factor were carried out on the ordered recall data for 2 N conditions at a time and the summary tables for these are given in Table 37.

NQ v. QQ comparison

Only the main effect of serial position reached significance ($F=46.77$; df 2,76; $p < .01$) and the comparisons between means for this main effect revealed that significantly more words were recalled from positions 1-4 than from positions 5-8 ($q=13.33$; df 3,76; $p < .01$) or

Table 36

% Ordered recall

	NN	NQ	QN	QQ
Trial 1	34.2	32.5	32.5	29.2
Trials 3-12	45.3	40.4	48.5	33.3

% Free recall

	NN	NQ	QN	QQ
Trial 1	51.7	55.0	54.2	48.2
Trials 3-12	56.7	52.8	60.6	50.0

Table 37

Anova - Noise x Serial position (Trial 1).

(1) NQ v. QQ

Source	SS	df	MS	F
Between subjects	37.47			
Noise (N)	0.54	1	0.54	< 1
Subj. w gps.	36.93	38	0.97	
Within subjects	152			
Serial position (SP)	83.27	2	41.63	46.77**
N x SP	1.26	2	0.63	< 1
SP x Subj. w gps.	67.47	76	0.89	

(2) QN v. QQ

Source	SS	df	MS	F
N	0.27	1	0.27	< 1
Subj. w gps.	35.97	28	1.28	
SP	31.72	2	15.86	14.68**
N x SP	5.86	2	2.93	2.71+
SP x Subj. w gps.	60.43	56	1.08	

(3) NN v. QN

Source	SS	df	MS	F
Between subjects	32.00	19		
N	0.06	1	0.06	< 1
Subj. w gps.	31.94	18	1.77	
Within subjects	69.33	40		
SP	23.33	2	11.66	9.96**
N x SP	3.74	2	1.87	1.60
SP x Subj. w gps.	42.26	36	1.17	

(4) NN v. NQ

Source	SS	df	MS	F
N	0.13	1	0.13	< 1
Subj. w gps.	32.90	28	1.17	
SP	53.72	2	26.86	30.52**
N x SP	1.07	2	0.53	< 1
SP x Subj. w gps.	49.30	56	0.88	

(5) NN v. QQ

Source	SS	df	MS	F
N	0.67	1	0.67	< 1
Subj. w gps.	29.97	28	1.07	
SP	41.06	2	20.53	20.33**
N x SP	0.13	2	0.06	< 1
SP x Subj. w gps.	56.43	56	1.01	

from positions 9-12 ($q=9.00$; df 3,76; $p < .01$). Similarly, significantly more words were recalled from positions 9-12 than from positions 5-8 ($q=4.33$; df 3,76; $p < .05$).

QN v. QQ comparison

Once again only the main effect of serial position reached significance ($F=14.68$; df 2,56; $p < .01$) and comparisons between means using Tukey's method showed that significantly more words were recalled from positions 1-4 than from positions 5-8 ($q=7.60$; df 3,56; $p < .01$) and more were recalled from positions 9-12 than from positions 5-8 ($q=4.85$; df 3,56; $p < .01$). The interaction between noise condition and serial position approached significance ($F=2.71$; df 2,56; $p < .10$) with N during recall tending to improve performance on later serial positions while having a detrimental effect on early serial positions.

NN v. QN comparison

Only the main effect of serial position reached significance ($F=9.96$; df 2,36; $p < .01$) and comparison between means using Tukey's method revealed that significantly more words were recalled from positions 1-4 than from positions 5-8 ($q=6.25$; df 3,36; $p < .01$) and more words were recalled from positions 9-12 than from positions 5-8 ($q=4.17$; df 3,36; $p < .05$).

NN v. NQ comparison

Once again only the main effect of serial position reached significance ($F=30.52$; df 2,56; $p < .01$) and comparisons between means showed that significantly more words were recalled from positions 1-4 than from positions 5-8 ($q=10.94$; df 3,56; $p < .01$) and from positions 9-12

($q=7.22$; df 3,56; $p < .01$). Similarly more words were recalled from positions 9-12 than from positions 5-8 ($q=3.72$; df 3,56; $p < .05$).

NN v. QQ comparison

Only the main effect of serial position reached significance ($F=20.33$; df 2,56; $p < .01$) and comparisons between means revealed that significantly more words were recalled from positions 1-4 than from positions 5-8 ($q=9.05$; df 3,56; $p < .01$) and from positions 9-12 ($q=6.05$; df 3,56; $p < .01$).

Separate 2x3 (Noise condition x Serial positions 1-4; 5-8; 9-12) analyses of variance having repeated measures on the second factor were also carried out on the free recall data for two N conditions at a time and the summary tables for these are shown in Table 38.

NQ v. QQ comparison

Only the main effect of serial position reached significance ($F=20.99$; df 2,76; $p < .01$) and comparisons between means revealed that significantly more words were recalled from positions 1-4 than from positions 5-8 ($q=8.44$; df 3,76; $p < .01$) and from positions 9-12 ($q=7.62$; df 3,76; $p < .01$). The main effect of noise during input compared with quiet throughout approached significance ($F=3.19$; df 1,38; $p < .10$) with noise improving performance.

QN v. QQ comparison

Only the main effect of serial position reached significance ($F=4.60$; df 2,56; $p < .05$) and comparisons between means revealed that significantly more words were recalled from positions 1-4 than from positions

Table 38

Anova - Noise x Serial position for free recall (Trial 1)

(1) QN v. QQ

Source	SS	df	MS	F
Between subjects	27.47			
Noise (N)	2.14	1	2.14	3.19+
Subj. w gps.	25.33	38	0.67	
Within subjects	126.00			
Serial position (SP)	44.51	2	22.25	20.99**
N x SP	0.62	2	0.31	< 1
SP x Subj. w gps.	80.87	76	1.06	

(2) QN v. QQ

Source	SS	df	MS	F
N	1.07	1	1.07	1.46
Subj. w gps.	20.57	28	0.73	
SP	10.40	2	5.20	4.60*
N x SP	7.06	2	3.53	3.12+
SP x Subj. w gps.	63.23	56	1.13	

(3) NN v. QN

Source	SS	df	MS	F
Between subjects	9.51	19		
N	0.14	1	0.14	<1
Subj. w gps.	9.37	18	0.52	
Within subjects	64.67	40		
SP	11.23	2	5.61	4.31*
N x SP	6.71	2	3.35	2.58+
SP x Subj. w gps.	46.73	36	1.30	

(4) NN v. NQ

Source	SS	df	MS	F
N	0.27	1	0.27	<1
Subj. w gps.	14.13	28	0.50	
SP	35.99	2	17.99	15.64**
N x SP	0.53	2	0.26	<1
SP x Subj. w gps.	64.37	56	1.15	

(5) NN v. QQ

Source	SS	df	MS	F
N	0.27	1	0.27	<1
Subj. w gps.	17.60	28	0.63	
SP	29.99	2	14.99	11.99**
N x SP	0.53	2	0.26	<1
SP x Subj. w gps.	70.10	56	1.25	

5-8 ($q=4.40$; df 3,56; $p < .01$). The interaction between noise condition and serial position approached significance ($F=3.12$; df 2,56; $p < .10$) with noise during recall improving performance on the later serial positions whilst having a detrimental affect on early positions.

NN v. QN comparison

Once again only the main effect of serial position reached significance ($F=4.31$; df 2,36; $p < .05$) and comparisons between means revealed that significantly more words were recalled from positions 1-4 than from positions 5-8 ($q=4.2$; df 3,36; $p < .05$). The interaction between noise condition and serial position approached significance ($F=2.58$; df 2,36; $p < .10$) with performance in the QN condition resulting in better recall on serial positions 9-12 but worse recall on positions 1-4.

NN v. NQ comparison

The main effect of serial position again reached significance ($F=15.64$; df 2,56; $p < .01$) and comparisons between means revealed that significantly more words were recalled from positions 1-4 than from positions 5-8 ($q=7.24$; df 3,56; $p < .01$) or from positions 9-12 ($q=6.19$; df 3,56; $p < .01$).

NN v. QQ comparison

A significant main effect of serial position was again observed ($F=11.99$; df 2,56; $p < .01$) and comparisons between means revealed that significantly more words were recalled from positions 1-4 than from positions 5-8 ($q=6.5$; df 3,56; $p < .01$) or from positions 9-12 ($q=5.14$; df 3,56; $p < .01$).

(ii) Results of Trials 3-12

The mean percentage correct in each N condition for both ordered and free recall is shown in Table 36.

Separate 2x3 (Noise condition; serial positions 1-4; 5-8; 9-12) analyses of variance having a repeated measure on the second factor were carried out on the ordered recall data for two N conditions at a time and the summary tables for these are given in Table 39.

NQ v. QQ comparison

The main effect of serial position reached significance ($F=69.99$; df 2,76; $p < .01$) and comparisons between means revealed that significantly more words were recalled from positions 1-4 than from positions 5-8 ($q=12.42$; df 3,76; $p < .01$) and significantly more were recalled from positions 9-12 than from positions 1-4 ($q=3.54$; df 3,76; $p < .05$) and from positions 5-8 ($q=15.96$; df 3,76; $p < .01$).

QN v. QQ comparison

In this analysis both the main effect of noise ($F=9.42$- df 1,28; $p < .01$) and serial position ($F=50.54$; df 2,56; $p < .01$) reached significance. Comparisons between means on the latter factor revealed that significantly fewer words were recalled from positions 5-8 than from positions 1-4 ($q=11.16$; df 3,56; $p < .01$) or from positions 9-12 ($q=13.14$; df 3,56; $p < .01$). The main effect of noise condition showed that significantly more words were recalled in the QN condition than in the QQ condition.

Table 39

Anova - Noise x Serial position for ordered recall (Trials 3-12)

(1) NQ v. QQ

Source	SS	df	MS	F
Between subjects	3,725.70			
Noise (N)	246.54	1	246.54	2.69
Subj. w gps.	3,479.16	38	91.56	
Within subjects	6,748.80			
Serial position (SP)	4,353,64	2	2,176.82	69.99**
N x SP	31.22	2	15.61	< 1
SP x Subj. w gps.	2,363.94	76	31.10	

(2) QN v. QQ

Source	SS	df	MS	F
N	739.95	1	739.95	9.42**
Subj. w gps.	2,198.88	28	78.53	
SP	3,004.98	2	1,502.49	50.54**
N x SP	1.07	2	0.53	< 1
SP x Subj. w gps.	1,664.87	56	29.73	

(3) NN v. QN

Source	SS	df	MS	F
Between subjects	1,756.23	19		
N	24.06	1	24.06	< 1
Subj. w gps.	1,732.17	18	96.23	
Within subjects	3,540.50	40		
SP	1,920.93	2	960.46	21.70^{**}
N x SP	26.14	2	13.07	< 1
SP x Subj. w gps.	1,593.43	36	44.26	

(4) NN v. NQ

Source	SS	df	MS	F
N	75.98	1	75.98	< 1
Subj. w gps.	3,012.45	28	107.59	
SP	2,448.05	2	1,224.02	29.90^{**}
N x SP	63.85	2	31.92	< 1
SP x Subj. w gps.	2,292.50	56	40.94	

(5) NN v. QQ

Source	SS	df	MS	F
N	463.88	1	463.88	8.71^{**}
Subj. w gps.	1,491.85	28	53.28	
SP	2,480.44	2	1,240.22	32.41^{**}
N x SP	23.73	2	11.86	< 1
SP x Subj. w gps.	2,142.70	56	38.26	

NN v. QN comparison

Only the main effect of serial position reached significance (F=21.70; df 2,36; $p < .01$) and comparisons between means showed that significantly fewer words were recalled from positions 5-8 than from positions 1-4 (q=7.58; df 3,36; $p < .01$) or from positions 9-12 (q=8.46; df 3,36; $p < .01$).

NN v. NQ comparison

Once again the main effect of serial position reached significance (F=29.90; df 2,56; $p < .01$) and comparisons between means revealed that significantly fewer words were recalled from positions 5-8 than from positions 1-4 (q=8.39; df 3,56; $p < .01$) or from positions 9-12 (q=10.26; df 3,56; $p < .01$).

NN v. QQ comparison

Both the main effects of noise (F=8.71; df 1,28; $p < .01$) and serial position (F=32.41; df 2,56; $p < .01$) reached significance. Comparisons between means for the latter effect revealed that significantly fewer words were recalled from positions 5-8 than from positions 1-4 (q=9.36; df 3,56; $p < .01$) or from positions 9-12 (q=10.27; df 3,56; $p < .01$). Performance in the NN condition was significantly better than that in QQ.

Separate 2x3 (Noise condition; serial positions 1-4; 5-8; 9-12) analyses of variance having a repeated measure on the second factor were also carried out on the free recall data for two N conditions at a time and the summary tables for these are given in Table 40.

Table 40

Anova - Noise x Serial position for free recall (Trials 3-12)

(1) NQ v. QQ

Source	SS	df	MS	F
Between subjects	2,338.63			
Noise (N)	39.68	1	39.68	< 1
Subj. w gps.	2,298.95	38	60.50	
Within subjects	5,226.70			
Serial position (SP)	2,904.65	2	1,452.32	51.55**
N x SP	181.35	2	90.67	3.22*
SP x Subj. w gps.	2,140.70	76	28.17	

(2) QN v. QQ

Source	SS	df	MS	F
N	358.31	1	358.31	6.61*
Subj. w gps.	1,518.77	28	54.24	
SP	1,803.28	2	901.64	33.71**
N x SP	7.86	2	3.93	< 1
SP x Subj. w gps.	1,498.03	56	26.75	

(3) NN v. QN

Source	SS	df	MS	F
Between subjects	1,315.85	19		
N	36.81	1	36.81	< 1
Subj. w gps.	1,279.04	18	71.06	
Within subjects	2,327.00	40		
SP	1,090.00	2	545.00	16.20**
N x SP	25.74	2	12.87	< 1
SP x Subj. w gps.	1,211.26	36	33.65	

(4) NN v. NQ

Source	SS	df	MS	F
N	45.99	1	45.99	< 1
Subj. w gps.	2,059.22	28	73.54	
SP	1,586.54	2	793.27	23.96**
N x SP	146.36	2	73.18	2.21
SP x Subj. w gps.	1,853.93	56	33.10	

(5) NN v. QQ

Source	SS	df	MS	F
N	142.10	1	142.10	4.22*
Subj. w gps.	942.07	28	33.64	
SP	1,373.39	2	686.69	18.24**
N x SP	19.19	2	9.59	< 1
SP x Subj. w gps.	2,108.03	56	37.64	

NQ v. QQ comparison

The main effect of serial position reached significance ($F=51.55$; df 2,76; $p < .01$) and comparisons between means revealed that significantly more words were recalled from positions 9-12 than from positions 1-4 ($q=3.87$; df 3.76; $p < .05$) and from positions 5-8 ($q=13.90$; df 3,76; $p < .01$). More words were also recalled from positions 1-4 than from positions 5-8 ($q=10.03$; df 3,76; $p < .01$). The interaction N x SP also reached significance ($F= 3.22$; df 2,76; $p < .05$) and this was analysed further for simple main effects and the summary table for this is given in Table 40a , from which it can be seen that the effects of N exert their influence on the recency portion of the curve, with performance in NQ being superior to that in QQ.

QN v. QQ comparison

Both the main effect of N ($F=6.61$; df 1,28; $p < .05$) and serial position ($F=33.71$; df 2,56; $p < .01$) reached significance. Performance under QN was superior to that under the control condition. Comparisons between means for the main effect of serial position revealed that significantly fewer words were recalled from positions 5-8 than from positions 1-4 ($q=9.55$; df 3,56; $p < .01$) or from positions 9-12 ($q=10.53$; df 3,56; $p < .01$).

NN v. QN comparison

Only the main effect of serial position reached significance ($F=16.20$; df 2,36; $p < .01$) and comparisons between means showed that significantly fewer words were recalled from positions 5-8 than from positions 1-4 ($q=6.54$; df 3,36; $p < .01$) or positions 9-12 ($q=7.31$; df 3,36; $p < .01$).

Table 40a

Summary Table for Simple Main Effects (N x SP) for Free Recall Analysis NQ v. QQ

Source	SS	df	MS	F
N at SP_1	28.90	1	28.90	< 1
N at SP_2	7.23	1	7.23	< 1
N at SP_3	184.90	1	184.90	4.75*
Error term		114	38.95	
SP at NQ	1,798.3	2	899.15	31.92**
SP at QQ	1,287.7	2	643.85	22.85**
Error		76	28.17	

NN v. NQ comparison

Once again only the main effect of serial position reached significance ($q=23.96$; df 2,56; $p < .01$) and comparisons between means revealed that significantly fewer words were recalled from positions 5-8 than from positions 1-4 ($q=6.64$; df 3,36; $p < .01$) or from positions 9-12 ($q=9.95$; df 3,36; $p < .01$).

NN v. QQ comparison

Both the main effect of noise condition ($F=4.22$; df 1,28; $p < .05$) and serial position ($F=18.24$; df 2,56; $p < .01$) reached significance. Performance was superior in the NN condition compared with performance in QQ. Comparisons between means for the main effect of serial position revealed that significantly fewer words were recalled from positions 5-8 than from positions 1-4 ($q=7.27$; df 3,56; $p < .01$) or from positions 9-12 ($q=7.50$; df 3,56; $p < .01$).

6.5.1 Comparison between Experiment 4 and Experiment 4A

Table 41 shows the mean percentage correct under each N condition for the two experiments and these are illustrated graphically in Figure 23

6.6 Discussion

As can be seen from Figure 23 the results of Experiment 4A are indeed similar to those of Experiment 4, with performance in QN being significantly better than that in QQ for both ordered recall and free recall of words as well as for the digits of Experiment 4. However, performance in NN was also significantly better than that in QQ for both the

Table 41

Mean % Correct Under Each N Condition

Experiment 4 (digits)

	NN	NQ	QN	QQ
Trial 1	55.5	40.0	52.2	35.5
Trials 6-55	63.0	58.9	72.2	57.3

Experiment 4A (ordered recall words)

	NN	NQ	QN	QQ
Trial 1	34.2	32.5	32.5	29.2
Trials 3-12	45.3	40.4	48.5	33.3

Figure 23 Figure showing probability of recall of words and digits as a function of noise condition - Experiments 4 and 4a.

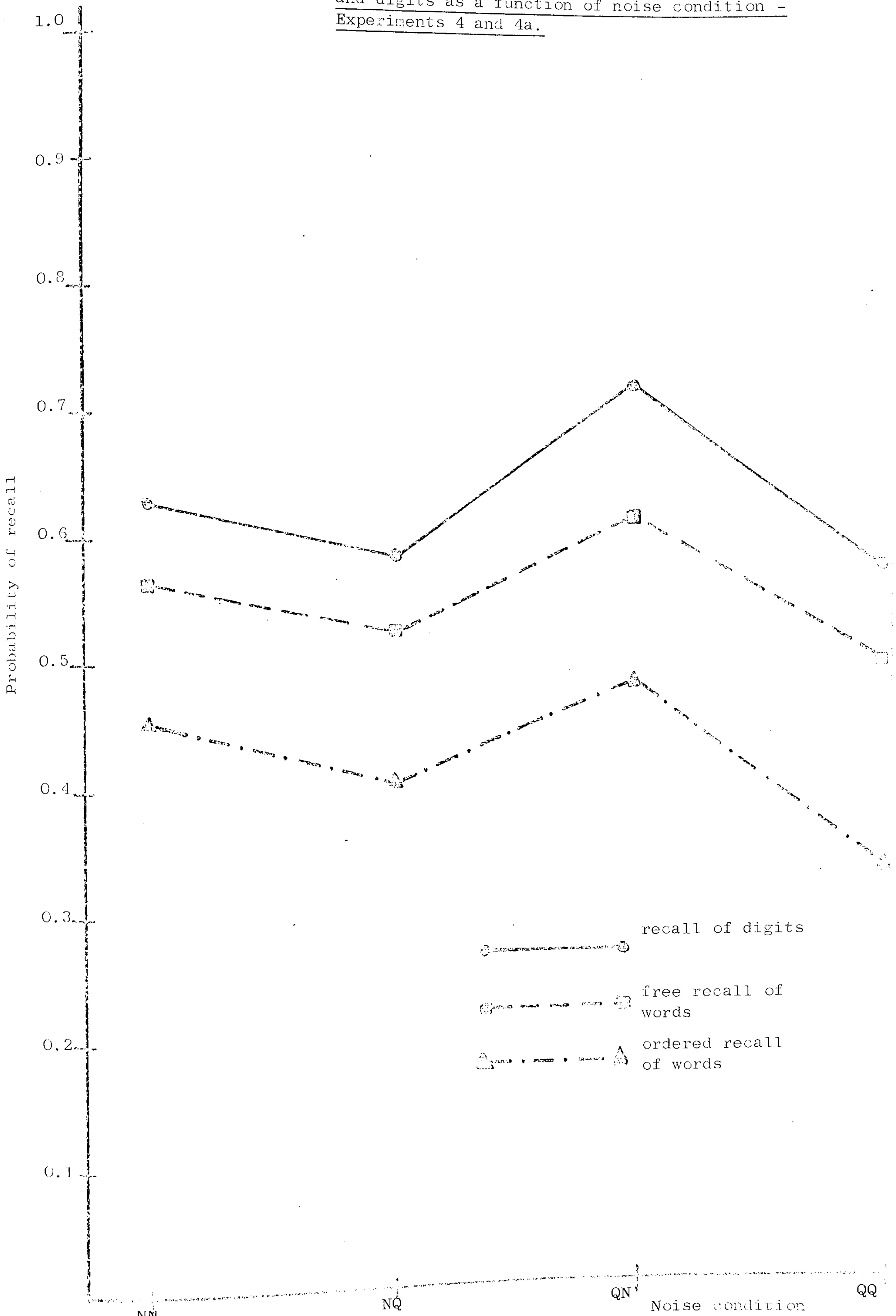


Figure 24 Figure showing the probability of recall (ordered recall) as a function of serial position for Trial 1 - Experiment 4a.

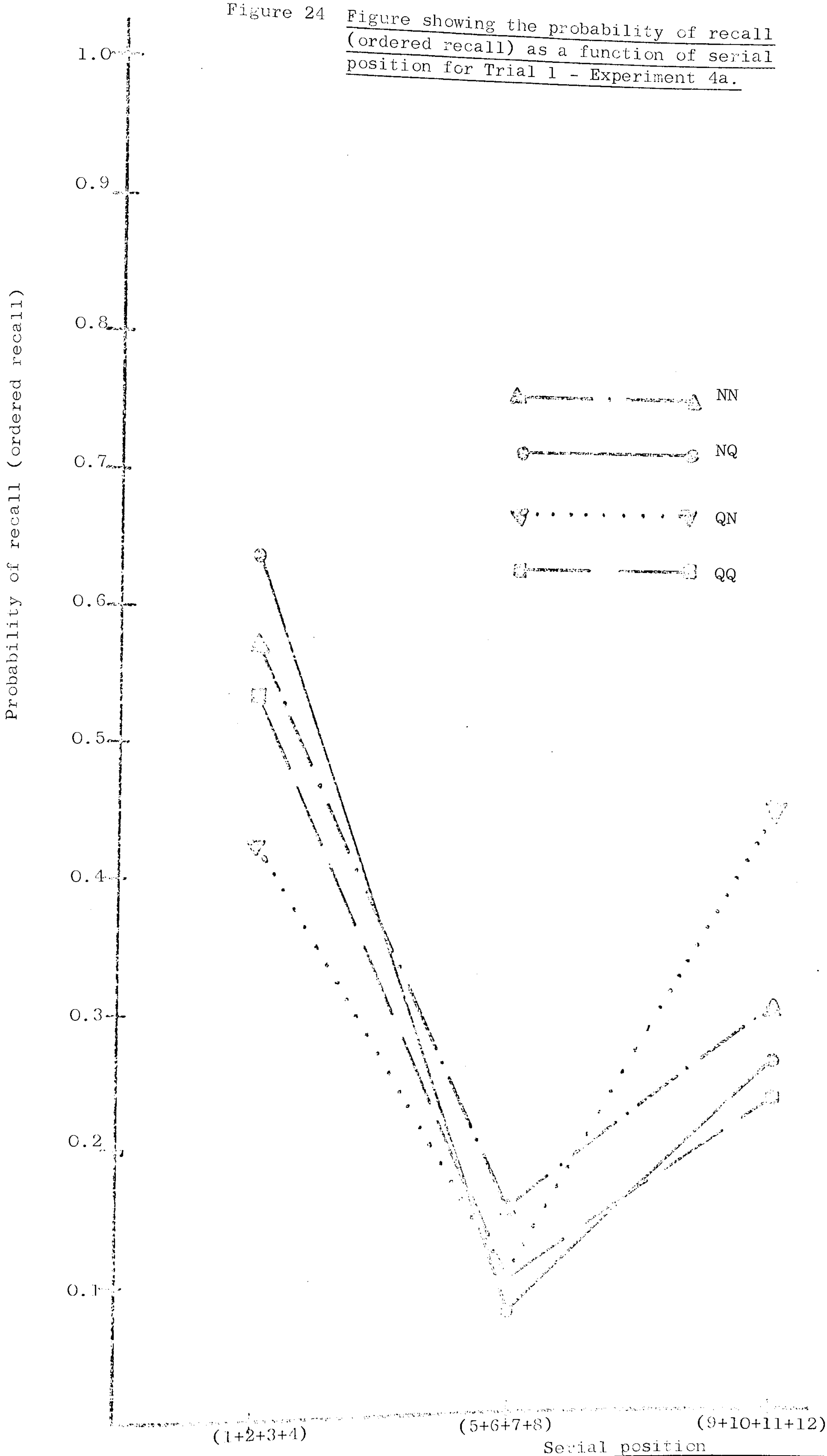


Figure 25 Figure showing probability of recall (free recall) as a function of serial position for Trial 1 - Experiment 4a.

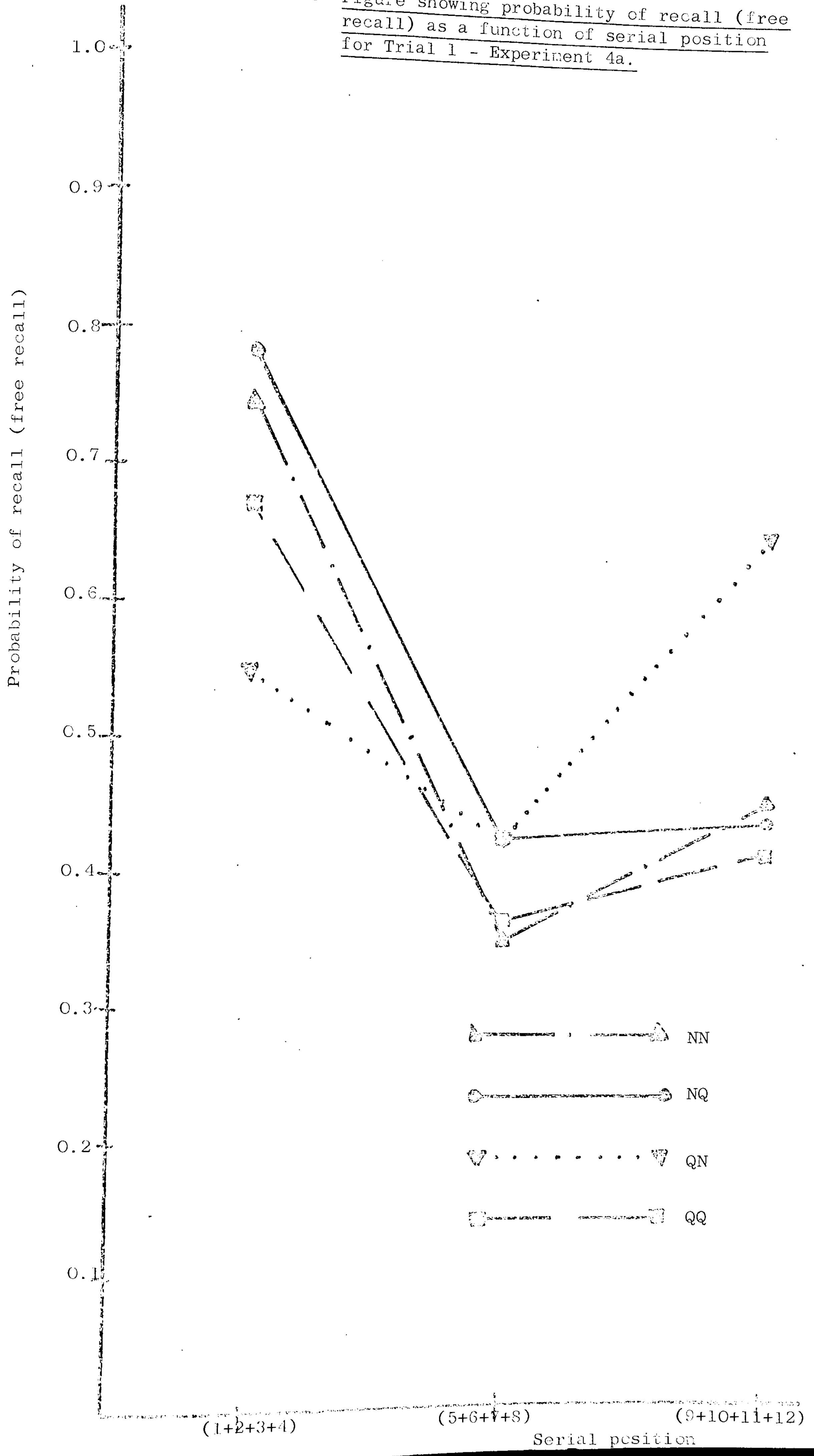


Figure 26 Figure showing the probability of recall (ordered recall) as a function of serial position for Trials 3-12 - Experiment 4a.

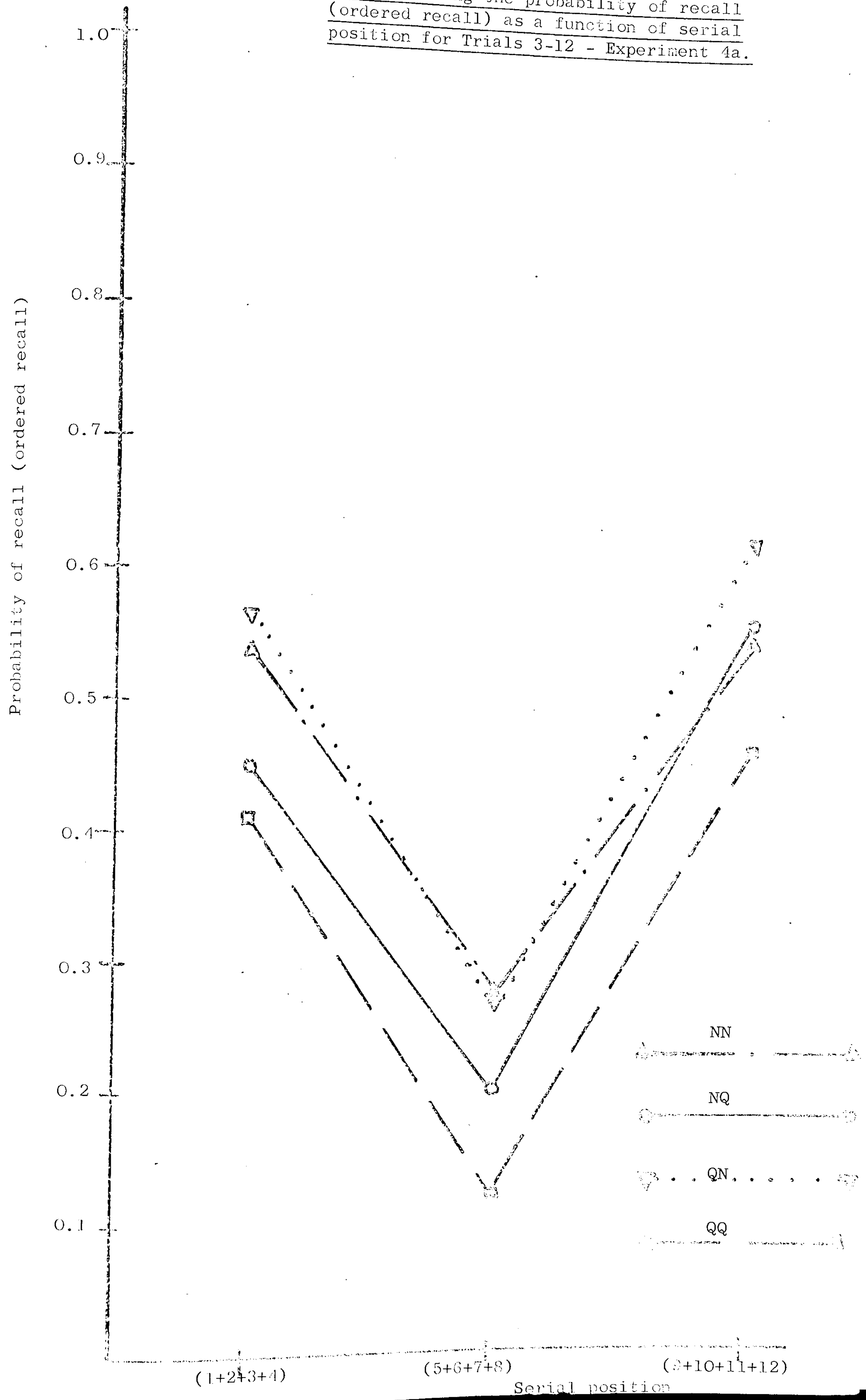
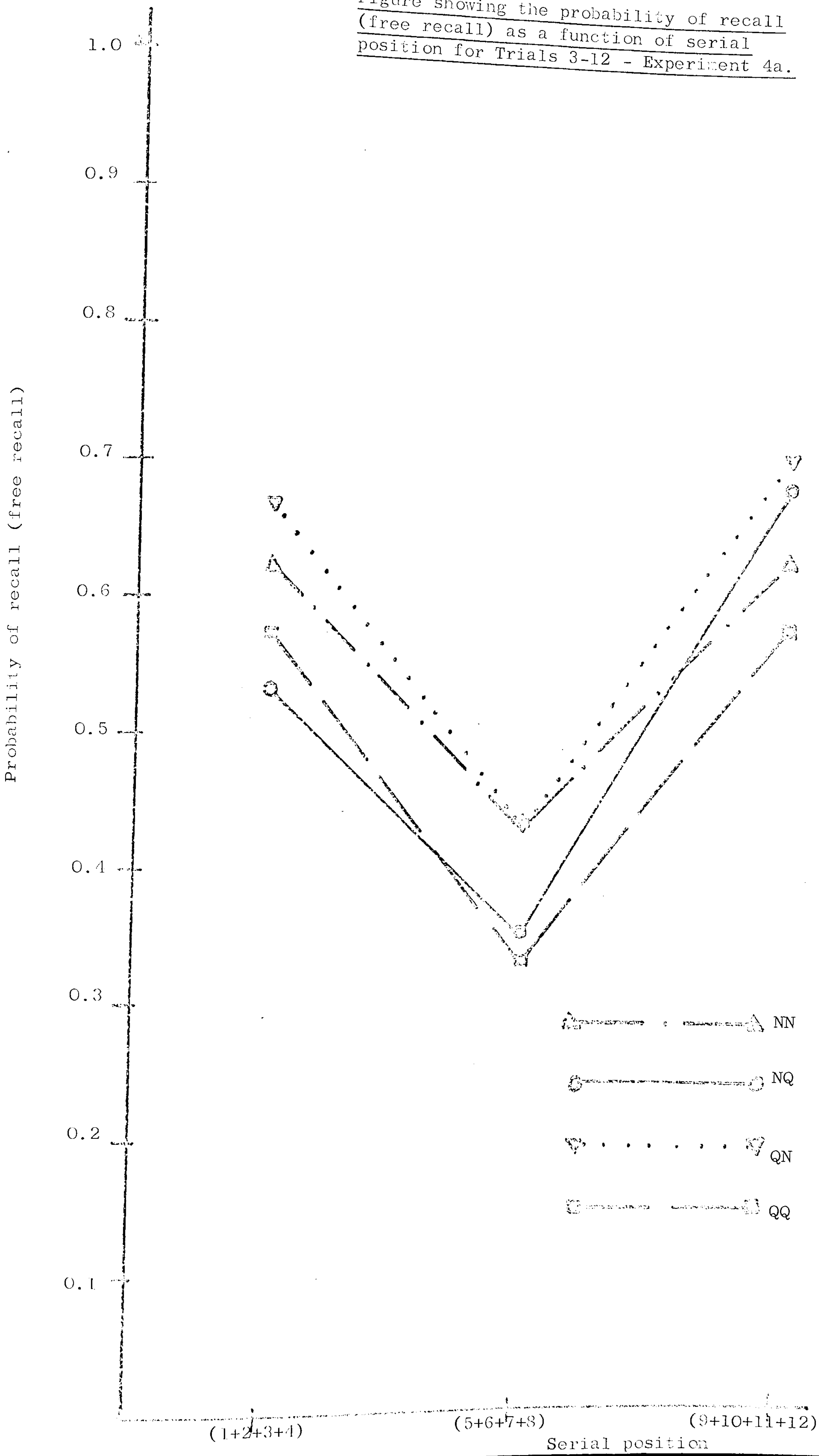


Figure 27 Figure showing the probability of recall (free recall) as a function of serial position for Trials 3-12 - Experiment 4a.



ordered and free recall of words, whereas this was not the case for digits, although in the latter case performance tended to be better in NN than QQ (63% compared with 57.3%) which is at least in the same direction. For the analyses of Trials 3-12 for words and Trials 6-50 for digits only the NQ v. QQ comparison for free recall yielded a significant interaction between N and SP. The SP curves for NQ and QQ in Experiment 4 produced similar graphs to those in the previous experiments but the interaction failed to reach significance. Thus N during input tends to improve performance on the recency portion of the curve for lists of digits as well as for lists of words, whereas performance on the early part of the curve tends to be worse in N. As suggested in previous experiments (Exps. 1 & 2) N during presentation appears to facilitate phonemic coding and when recall takes place under quiet conditions this tends to result in better performance in N on recency positions. However, the results of Experiment 4 and Experiment 4A suggest that the main effects of N tend to occur during retrieval. If there are two retrieval modes as proposed by Lockhart et al. (1976) then the present results could be explained by suggesting that N during recall encourages subjects to adopt a different retrieval strategy from that employed in Q recall. It is suggested that subjects recalling in N adopt the reconstructive strategy rather than the scanning operation employed in Q. If this is the case, then for both Experiment 4 and Experiment 4A, the reconstructive retrieval strategy appears to result in better recall. However, performance in QN tended to be better than that in NN and this difference is possibly due to the different conditions at input. If, as was suggested in Experiment 2, working in noise encourages subjects to adopt phonemic coding rather than the deeper levels of coding, then the observed tendency of superior performance in QN compared with NN would be expected since the reconstruction strategy is considered to require deeper levels of processing. The comparison between the NQ and QQ condition suggests that if N at input encourages phonemic coding then this type of encoding has a tendency to result in slightly better performance when the scanning retrieval strategy is employed which is in agreement with the proposals outlined by Lockhart, Craik and Jacoby (1976).

If subjects order of report of responses is related to their retrieval strategies, the hypothesised difference in retrieval strategy adopted in N and Q could be reflected in differences in the number recorded in order 1-9.

In discussing the scanning strategy, Craik and Jacoby (1975) suggest that this is a search process which proceeds backwards from the present, while in the reconstruction strategy S attempts to develop a percept which approximates the structure of the episodic trace. It is considered a possibility in the present experiment that if S is employing a reconstruction strategy he might be more likely to recall in the order 1-9, since this is the order in which the stimuli were presented, particularly for such a short list. The results of Experiment 4 tend to support this suggestion. It can be seen from Table 31 that there is a tendency for more responses to be in the order 1-9 in NN compared with NQ and in QN compared with QQ. Similarly one might expect a positive correlation between the number of responses written down in the order 1-9 and the total number of digits correct when subjects recall in N; whereas this may not be the case in Q recall if a subject adopts a backward scanning strategy. From Table 35 it can be seen that during recall in N, the correlation tends to be very low, but positive, whereas when recall is in Q, the correlation tends to be negative (significantly so in the case of QQ). These results suggest that when subject is recalling in N, there is a tendency for performance to be better when recalling in the order 1-9, than in other orders, whereas when subjects recall in Q, responding in the order 1-9 is certainly not the best order of recall.

However, one other point seems to emerge when considering the number recorded in the order 1-9 and this is that the input condition may also have an effect on the number of responses in this order. Comparing the NN and QN condition, there is a tendency for more responses in the order 1-9 after N at input and this is also the case with the NQ v. QQ comparison. While it is not clear why this should occur, a possible reason might be the different types of rehearsal involved in processing to different levels. Craik and Watkins (1973) distinguish two types of rehearsal - maintenance rehearsal in which subjects merely maintain activity at one level of analysis i.e. repeat encoding operations already accomplished and elaborative rehearsal in which subjects perform further more elaborative analyses, resulting in a richer, more unique encoding of the item. This distinction between the maintenance and elaborative aspects of rehearsal (primary and secondary rehearsal) is also made by Bjork (1975) who suggests that "primary rehearsal is a fundamental maintenance operation not only in the sense that items are kept available in STS but also in the sense that the ordering of these items is also preserved. On the other hand, secondary rehearsal elaborates, integrates and re-arranges the items in STS" (p.160). This would seem to suggest that if subjects maintained items at less deep levels of processing, as appears to be the case in N, rather than processing to deeper levels and employing elaborative rehearsal, then this might account for the tendency for subjects to write more responses in the order 1-9 after receiving the input in N then in Q. Bjork and Jongeward (1974) also suggested that order information in STS tends to be maintained by primary rehearsal and lost as a consequence of secondary rehearsal.

If N during recall affects subjects retrieval strategy (as suggested by the present experiment) and if N affects subjects level of arousal (Davies, 1968; Hockey, 1969) then the results of the present experiment suggest that arousal level during recall can affect retrieval strategy, and other experimenters who have attempted to manipulate arousal level during recall using other techniques have produced similar findings, although their interpretations have been different. Pessin (1933) had sixty subjects learn three lists of nonsense syllables. Some subjects learned the lists while they were alone, while other subjects learned the lists in the presence of several spectators. There was little difference in the number of trials required to learn the nonsense syllables, although the presence of others tended to result in worse learning. However, Pessin also varied the recall condition a few days after the list had been learned. Subjects recalled the lists by re-learning then either alone or in the presence of others. Pessin found that the recall of the syllables was facilitated in the presence of an audience. If the presence of others has motivational consequences (Zajonc, 1965) and increased motivation increases the general arousal level of the organism (Birch and Veroff, 1966) then the results of Pessin suggest that high arousal during recall results in improved performance. Similarly Bourne (1955) investigated the effects of induced muscular tension upon paired associate learning. Four experimental conditions were employed: (i) TT (tension during input and recall) (ii) TN (tension during input, no tension during recall, (iii) NT, (iv) NN. Bourne's results showed that recall under tension was consistently better than recall under no tension. On the other hand, recall performance was no better whether learning took place under tension or no tension. Bourne interprets his results as being in accord with the concept of tension as a drive.

Although it is not clear how paired associate learning relates to STM or how social facilitation and induced muscle tension affect a general state of arousal, if such exists. Nevertheless the results of Zajonc and Bourne do fit in well with those of the present experiment and could possibly be interpreted as suggesting that high arousal affects retrieval strategy.

In conclusion, the present experiment indicates that N during recall may affect subjects retrieval strategy, with N encouraging subjects to adopt the reconstructive mode of retrieval rather than the scanning operation adopted in Q. Differences in subjects order of report of responses were also discussed in the light of possible differences in retrieval strategy.

CHAPTER 7

NOISE AND PRESENTATION RATE

Craik and Lockhart (1972) described the processing of a stimulus in terms of a continuum of analysing operations. First the physical and structural features of the stimulus are analysed, then the stimulus is subjected to progressively more elaborate semantic analyses. The phrase "greater depth' referred to these later semantic-associative operations. It was further postulated that the memory trace was a by-product of the analysing operations and that the durability of the trace was a function of depth - deeper initial processing yields a longer lasting trace. With regard to an independent index of processing depth, they suggested that when other things are held constant, deeper levels of processing would require longer processing times. However, Craik and Tulving (1975) suggest that processing time cannot always be taken as an absolute indicator of depth, since highly familiar stimuli (e.g. simple phrases or pictures) can be rapidly analysed to a complex meaningful level. But they point out that, "within one class of materials, or better, with one specific stimulus deeper processing is assumed to require more time" (Craik and Tulving, 1975 p.271). However, evidence that semantic encoding requires more time than phonemic encoding is given in Shulman (1970). Thus changing the presentation rate of the stimuli in an experiment similar to Experiment 4 would result in different amounts of time available for processing with faster presentation rates possibly preventing processing to deeper levels because of lack of time.

In the case of visually presented material, several studies (Pollack, 1963; Murdock, 1963; Mackworth, 1962) have shown that recall improves as the presentation rate becomes slower. Bergstrom (1907), holding the exposure time constant and varying the rate, found better recall with a slower rate, so that improvement is not necessarily due to the stimulus remaining visible longer (see Aaronson, 1967 for a review of studies on presentation rate).

If working in noise encourages subjects to employ phonemic coding rather than deeper levels of coding then in an experiment where presentation rate is increased so that subjects do not have time to process more deeply even in quiet then the effects of noise on coding should not be obtained at faster presentation rates unless N actually facilitates phonemic coding rather than merely encouraging subjects to adopt it. It was therefore decided to examine the effects of N on the immediate recall of serially presented digit strings presented at different rates. Although the same recall situation (subjects were to record the digits in their correct boxes, but could write them down in any order) was employed as in previous experiments the order of recall was again recorded as in Experiment 4, since Posner (1964) suggests that the order of recall is an important factor in determining presentation rate effects.

7.1 Method

7.1.1 Subjects

Sixty six undergraduates, 32 males and 34 females, aged between 18 and 25 years, served as subjects and were paid for their services. Subjects were randomly allocated to one of four experimental conditions: noise during presentation and recall (NN); noise during presentation but not during recall (NQ); quiet during presentation and noise during recall (QN); quiet during presentation and recall (QQ). Fourty six subjects, 11 males and 12 females were assigned to both the NN and QQ conditions, and 10 subjects, 5 males and 5 females, were assigned to both the NQ and QN conditions. Subjects were tested individually.

7.1.2 Apparatus

A list of 90 9-digit sequences was compiled using random number tables with the restriction that no digit could appear more than once in a particular sequence or in the same serial position for two successive sequences; zero was not used. The digits were punched on to 6 paper-tapes in Binary Coded Decimal which corresponded to 6 orders of presentation. Three rates of presentation were employed 1/sec. (a), 2/sec. (b), 3/sec. (c) and these were presented in the following six orders:

Tape 1	abccbaabc
" 2	bcaacbbca
" 3	cabbaccab
" 4	acbbcaacb
" 5	baccabbac
" 6	cbaabccba

On each tape, therefore, there were 30 9-digit sequences at each rate.

The Binary Coded punched tape was fed into an Elliot photo-electric tape reader, the data output of which was fed into a binary to decimal convertor and presented on a Mallard Numerical Inaccatior ZM1020.

Immediately above the Numerical Indicator was fitted a small light which acted as a warning signal.

The same noise tape as in the previous experiments was used and once again it was played on a Ferrograph Series 7 recorder. As in Experiment 4, the noise was presented to subjects over head-phones. The volume control of the tape-recorder was adjusted until the noise level at the central point of the head-phone was either 90dB or 65dB.

7.1.3 Procedure

The subject was seated at a table in such a position that the Numerical Indicator was easily seen. He was instructed that when the light above the Numerical Indicator was extinguished he would be shown a sequence of 9-digits, one at a time. When the light reappeared (for 2 secs.) at the end of the sequence he was to write down the digits on the specially prepared response sheets containing rows of 9 boxes. The subject was required to put each digit in the sequence in the box corresponding to its position in the list. If the subject was unsure of a response he must guess rather than leave any of the 9 boxes blank. As in the previous experiments the subject was free to fill in the boxes in any order, although his order of recall was recorded in the same manner as in Experiment 4, but once again the subject was not informed of this.

After the experimenter had ensured that the instructions had been understood the experiment began. Each digit was presented for a constant time of 1/3 second for all presentation rates, and the total presentation time for a sequence was thus 9 seconds for the sequences presented at 1 digit/second, $4\frac{1}{2}$ seconds for those at 2 digits/second, and 3 seconds for those at 3 digits/second. The subject was allowed 15 seconds to complete his recall, but after 13 seconds of this period, the warning light came on for 2 seconds to indicate to the subject that the next sequence was about to start. Altogether subjects received 90 sequences of 9-digits. Subjects in the NN group received noise at a level of 90dB throughout the experiment and those in the QQ group, at a level of 65dB throughout. However, subjects in the NQ group received noise at a level of 90dB during presentation of the digits and at a level of 65dB during recall, while subjects in the QN group received these conditions in reverse order.

As in the previous experiments care was taken to control for possible TOD effects.

7.2 Results

The anlysis of the results is divided into two sections: (i) the analysis of the results of the first trial at each rate and (ii) the analysis of the results of trials 6-80. In both, the analysis is undertaken by step-wise comparisons between two N conditions at a time. Results of analyses involving all four N conditions are given in Appendix 5.

(i) Results of Trial 1 only

Recall performance was assessed by considering the total number of digits recorded in their correct serial position, and Table 42 shows the mean percentage correct in each noise condition for each presentation rate separately. Separate 2x3x3 (Noise condition; Rate 1/S;

Table 42

% Recalled in Each Condition

	NN	NQ	QN	QQ
Trial 1				
1/S	61.8	43.3	63.3	49.8
2/S	59.4	52.2	50.0	50.2
3/S	42.5	27.8	33.3	36.7
All Trials				
1/S	67.5	65.0	70.8	60.3
2/S	62.7	57.9	65.1	57.9
3/S	55.0	49.9	56.3	50.4

% Recalled Order 1-9

	NN	NQ	QN	QQ
1/S	72.0	61.2	38.4	58.4
2/S	69.6	65.6	38.0	60.0
3/S	73.2	63.6	45.6	60.0

2/S; 3/S; Serial position 1-3; 4-6; 7-9) analyses of variance having repeated measures on the last two factors were carried out for two N conditions at a time and summary tables for these are shown in Table 43a.

NQ v. QQ comparison

Both the main effect of rate ($F=4.06$; df 2,62; $p < .05$) and serial position ($F=44.11$; df 2,62; $p < .01$) reached significance. Comparisons between means for the main effect of rate revealed that significantly more digits were recalled with a presentation of 2/S than with a presentation rate of 3/S. Comparisons between means for the main effect of serial position revealed that significantly more digits were recalled from positions 1-3 than from positions 5-6 ($q=11.22$; df 3,62; $p < .01$) or from positions 7-9 ($q=12.44$; df 3,62; $p < .01$). The interaction N x SP approached significance ($F=2.48$; df 2,62; $p < .10$) with performance in NQ tending to result in worse performance on early serial positions, but slightly better performance on later positions

QN v. QQ comparison

Both the main effect of rate ($F=5.32$; df 2,62; $p < .05$) and serial position ($F=37.52$; df 2,62; $p < .01$) reached significance. Comparisons between means for the main effect of rate revealed that significantly more digits were recalled when presented at the rate of 1/S than when presented at the rate of 3/S ($q=4.64$; df 2,62; $p < .01$), but the other comparisons failed to reach significance. Comparisons between means for the main effect of serial position showed that significantly more digits were recalled from positions 1-3 than from

Table 43a

Anova - Noise x Rate x Serial position (Trial 1 only)

(1) NQ v. QQ

Source	SS	df	MS	F
Noise (N)	1.11	1	1.11	< 1
Subj. w gps.	59.08	31	1.90	
Rate (R)	14.78	2	7.39	4.06*
N x R	1.25	2	0.62	< 1
R x Subj. w gps.	112.87	62	1.82	
Serial position (SP)	64.40	2	32.20	44.11**
N x SP	3.62	2	1.81	2.48+
SP x Subj. w gps.	45.16	62	0.73	
R x SP	1.25	4	0.31	< 1
N x R x SP	1.25	4	0.31	< 1
R x SP x Subj. w gps.	88.52	124	0.71	

(2) QN v. QQ

Source	SS	df	MS	F
N	0.70	1	0.70	<1
Subj. w gps.	55.61	31	1.79	
R	18.40	2	9.20	5.32*
N x R	3.07	2	1.53	<1
R x Subj. w gps.	107.37	62	1.73	
SP	58.55	2	29.27	37.52**
N x SP	5.16	2	2.58	3.31+
SP x Subj. w gps.	48.67	62	0.78	
R x SP	6.83	4	1.71	1.96
N x R x SP	3.48	4	0.87	1.00
R x SP x Subj. w gps.	107.88	124	0.87	

(3) NN v. QN

Source	SS	df	MS	F
N	1.67	1	1.67	<1
Subj. w gps.	88.23	31	2.85	
R	23.84	2	11.92	11.46**
N x R	1.53	2	0.76	<1
R x Subj. w gps.	64.69	62	1.04	
SP	43.77	2	21.88	26.05**
N x SP	1.81	2	0.90	1.07
SP x Subj. w gps.	52.37	62	0.84	
R x SP	1.39	4	0.35	<1
N x R x SP	9.62	4	2.40	2.64*
R x SP x Subj. w gps.	112.85	124	0.91	

(4) NN v. NQ

Source	SS	df	MS	F
N	10.04	1	10.04	3.39+
Subj. w gps.	91.70	31	2.96	
R	18.54	2	9.27	8.20**
N x R	1.39	2	0.69	<1
R x Subj. w gps.	70.19	62	1.13	
SP	48.93	2	24.46	30.96**
N x SP	0.97	2	0.48	<1
SP x Subj. w gps.	48.86	62	0.79	
R x SP	0.97	4	0.24	<1
N x R x SP	2.23	4	0.56	<1
R x SP x Subj. w gps.	93.49	124	0.75	

(5) NN v. QQ

Source	SS	df	MS	F
Between subjects	99.05	45		
N	7.57	1	7.57	3.64+
Subj. w gps.	91.48	44	2.08	
Within subjects	476.45	368		
R	20.47	2	10.23	7.41**
N x R	0.62	2	0.31	<1
R x Subj. w gps.	121.36	88	1.38	
SP	126.51	2	63.25	84.33**
N x SP	1.88	2	0.94	1.25
SP x Subj. w gps.	66.07	88	0.75	
R x SP	1.87	4	0.47	<1
N x R x SP	3.71	4	0.93	<1
R x SP x Subj. w gps.	133.97	176	0.76	1.22

from positions 4-6 ($q=9.9$; df 3,62; $p < .01$) or positions 7-9 ($q=10.6$; df 3,62; $p < .01$). The interaction N x SP also reached significance ($F=3.31$; df 2,62; $p < .05$) and was analysed further for simple main effects, the summary table of which can be seen in Table 43b.

NN v. QN comparison

Both the main effects of rate ($F=11.46$; df 2,62; $p < .01$) and serial position ($F=26.05$; df 2,62; $p < .01$) reached significance. Comparisons between means for the main effect of rate revealed that significantly fewer digits were recalled at the fastest presentation rate i.e. 3/S than at the rate of 2/S ($q=4.54$; df 3,62; $p < .01$) or at the rate of 1/S ($q=6.73$; df 3,62; $p < .01$). Comparisons between means for the main effect of serial position showed that significantly more digits were recalled from positions 1-3, than from positions 4-6 ($q=8.7$; df 3.62; $p < .01$) or from positions 7-9 ($q=9.0$; df 3,62; $p < .01$). The interaction N x R x SP also reached significance ($F=2.64$; df 4,124; $p < .05$).

NN v. NQ comparison

Once again both the main effects of rate ($F=8.20$; df 2,62; $p < .01$) and serial position ($F=30.96$; df 2,62; $p < .01$). Comparisons between means for the main effect of rate revealed that significantly fewer digits were recalled at the fastest presentation rate (3/S) than at the rate of 2/S ($q=5.17$; df 3,62; $p < .01$) or at the rate of 1/S ($Q=4.42$; df 3,62; $p < .01$). Comparisons between means for the main effect of serial position revealed that significantly more digits were recalled from positions 1-3 than from positions 4-6 ($q=9.10$;

Table 43b

Summary Table for Simple Main Effects (N x SP)

(2) QN v. QQ

Source	SS	df	MS	F
N at SP_1	1.39	1	1.39	1.24
N at SP_2	0.14	1	0.14	<1
N at SP_3	4.32	1	4.32	3.86+
Error		93		
SP at N_1 (QQ)	47.81	2	23.90	30.65**
SP at N_2 (QN)	15.89	2	7.94	10.18**
Error		62	0.78	

df 3,62; p < .01) or from positions 7-9 (q=9.70; df 3,62; p < .01). The main effect of noise (F=3.39; df 1,31; p < .10) approached significance with performance in NN tending to be better than that in NQ.

NN v. QQ comparison

The main effects of rate (F=7.41; df 2,88; p < .01) and serial position (F=84.33; df 2,88; p < .01) again reached significance. Comparisons between means for the main effect of rate revealed that significantly fewer digits were recalled at the fastest presentation rate than at the rate of 2/S (q=4.55; df 3,88; p < .01) or at the rate of 1/S (q=4.85; df 3,88; p < .01). Comparisons between means for the main effect of serial position showed that significantly more digits were recalled from positions 1-3 than from positions 4-6 (q=15.14; df 3,88; p < .01) and from positions 7-9 (q=18.0; df 3,88; p < .01). The main effect of N also approached significance (F=3.64; df 1.44; p < .10) with performance in NN tending to be better than that in QQ.

(ii) Results of Trials 6-80

Recall performance was assessed by considering the total number of digits recorded in their correct serial position and Table 42 shows the mean percentage correct in each noise condition for each presentation rate separately. The mean percentage written down in the order 1-9 for each noise condition is also shown in this Table. Separate 2x3 (N condition rate 1/S; 2/S; 3/S) analyses of variance having repeated measures on the last factor were carried out on the data on the order

1-9 for two N conditions at a time and the summary tables for these are given in Table 44 , from which it can be seen that all the main effects apart from one failed to reach significance as did all the interactions. However, significantly more lists of digits were recalled in the order 1-9 in the NN than in the QN condition.

Separate 2x3x3 (Noise condition; rate 1/S; 2/S; 3/S; serial positions 1-3; 4-6; 7-9) analyses of variance having repeated measures on the second and third factors were carried out on the recall data for 2N conditions at a time and the summary tables for these are given in Table 45.

<u>NQ v. QQ comparison</u>

The main effects of rate (F=22.84; df 2,62; $p < .01$) and serial position (F=34.09; df 2,62; $p < .01$) reached significance. Comparisons between means for the former effect revealed that significantly more digits were recalled at the presentation rate of 1/S than at 2/S (q=3.61; df 3,62; $p < .05$) or at 3/S (q=9.48; df 3,62; $p < .01$). More digits were also recalled at the rate of 2/S than at the rate of 3/S (q=5.88; df 3,62; $p < .01$). Comparisons between means for the main effect of serial position revealed that significantly more digits were recalled from positions 1-3 than from positions 4-6 (q=7.89; df 3,62; $p < .01$) or from positions 7-9 (q=11.40; df 3,62; $p < .01$). Also, significantly more digits were recalled from positions 4-6 than from positions 7-9 (q=3.51; df 3,62; $p < .05$). The first order interaction (R x SP) also reached significance (F=8.16; df 4,124; $p < .01$). This was analysed further for simple main effects and the summary table is given in Table 45.

Table 44

Anova - Noise x Rate (number order 1-9)

(1) NQ v. QQ

Source	SS	df	MS	F
Noise (N)	20.63	1	20.63	<1
Subj. w gps.	7,140.54	31	230.34	
Rate (R)	7.94	2	3.97	<1
N x R	1.95	2	0.97	<1
R x Subj. w gps.	661.30	62	10.67	

(2) QN v. QQ

Source	SS	df	MS	F
N	463.23	1	463.23	2.09
Subj. w gps.	6,873.91	31	221.74	
R	19.65	2	9.82	1.02
N x R	13.66	2	6.83	<1
R x Subj. w gps.	595.83	62	9.61	

(3) NN v. QN

Source	SS	df	MS	F
N	1,258.08	1	1,258.08	6.76*
Subj. w gps.	5,765.48	31	185.98	
R	28.72	2	14.36	1.80
N x R	8.78	2	4.39	<1
R x Subj. w gps.	493.30	62	7.96	

(4) NN v. NQ

Source	SS	df	MS	F
N	88.38	1	88.38	< 1
Subj. w gps.	6,032.11	31	194.58	
R	2.51	2	1.25	< 1
N x R	11.57	2	5.78	< 1
R x Subj. w gps.	558.77	62	9.01	

(5) NN v. QQ

Source	SS	df	MS	F
Between subjects	9,402.62			
N	319.57	1	319.57	1.55
Subj. w gps.	9,083.05	44	206.43	
Within subjects	946.66			
R	4.36	2	2.18	< 1
N x R	7.43	2	3.71	< 1
R x Subj. w gps.	934.87	88	10.62	

Table 45

Anova - Noise x Rate x Serial position (Trials 6-80)

(1) NQ v. QQ

Source	SS	df	MS	F
Noise (N)	70.95	1	70.95	< 1
Subj. w gps.	18,563.20	31	598.81	
Rate (R)	3,754.32	2	1,877.16	22.84**
N x R	191.12	2	95.56	1.16
R x Subj. w gps.	5,094.51	62	82.17	
Serial position (SP)	21,234.80	2	10,617.40	34.09**
N x SP	64.96	2	32.48	< 1
SP x Subj. w gps.	19,310.40	62	311.46	
R x SP	796.25	4	199.06	8.16**
N x R x SP	126.30	4	31.57	1.29
R x SP x Subj. w gps.	3,023.52	124	24.38	

Summary Table for Simple Main Effects (R x SP)

Source	SS	df	MS	F
R at SP_1	251.06	2	125.53	2.88+
R at SP_2	2,859.93	2	1,429.96	32.77**
R at SP_3	1,439.58	2	719.79	16.49**
Error		186	43.64	
SP at R_1	4,789.23	2	2,394.61	19.94**
SP at R_2	7,518.96	2	3,759.48	31.31**
SP at R_3	9,723.01	2	4,861.50	40.49**
Error		186	120.07	

(2) QN v. QQ

Source	SS	df	MS	F
Noise (N)	2,182.03	1	2,182.03	2.51
Subj. w gps.	26,941.98	31	869.10	
Rate (R)	3,641.27	2	1,820.63	24.64**
N x R	133.68	2	66.84	< 1
R x Subj. w gps.	4,580.50	62	73.88	
SP	14,849.72	2	7,424.86	23.03**
N x SP	1,106.28	2	553.14	1.71
SP x Subj. w gps.	19,991.42	62	322.44	
R x SP	697.84	4	174.46	7.27**
N x R x SP	207.01	4	51.75	2.16+
R x SP x Subj. w gps.	2,975.26	124	23.99	

Summary Table for Simple Main Effects (R x SP)

Source	SS	df	MS	F
R at SP_1	208.40	2	104.20	2.56
R at SP_2	2,354.74	2	1,177.37	28.98**
R at SP_3	1,775.96	2	887.98	21.86**
Error		186	40.62	
SP at R_1	3,364.42	2	1,682.21	13.62**
SP at R_2	4,074.52	2	2,037.26	16.50**
SP at R_3	8,108.62	2	4,054.31	32.84**
Error		186	123.47	

(3) NN v. QN

Source	SS	df	MS	F
N	188.47	1	188.47	< 1
Subj. w gps.	46,782.71	31	1,509.12	
R	4,365.87	2	2,182.93	39.37^{**}
N x R	24.39	2	12.19	< 1
R x Subj. w gps.	3,437.88	62	55.45	
SP	9,869.94	2	4,934.97	17.62^{**}
N x SP	34.15	2	17.07	< 1
SP x Subj. w gps.	17,363.48	62	280.06	
R x SP	1,152.28	4	288.07	8.59^{**}
N x R x SP	78.48	4	19.62	< 1
R x SP x Subj. w gps.	4,159.13	124	33.54	

Summary Table for Simple Main Effects (R x SP)

Source	SS	df	MS	F
R at SP_1	133.82	2	66.91	1.64
R at SP_2	2,513.66	2	1,256.83	30.77^{**}
R at SP_3	2,870.66	2	1,435.33	35.14^{**}
Error		186	40.84	
SP at R_1	1,414.91	2	707.45	6.11^{**}
SP at R_2	2,678.15	2	1,339.07	11.57^{**}
SP at R_3	6,929.15	2	3,464.57	29.94^{**}
Error		186	115.71	

(4) NN v. NQ

Source	SS	df	MS	F
N	602.76	1	602.76	< 1
Subj. w gps.	38,403.94	31	1,238.84	
R	4,513.49	2	2,256.74	35.40**
N x R	47.26	2	23.63	< 1
R x Subj. w gps.	3,951.88	62	63.74	
SP	14,611.91	2	7,305.95	27.15**
N x SP	635.94	2	317.97	1.18
SP x Subj. w gps.	16,682.45	62	269.07	
R x SP	1,107.95	4	276.99	8.16**
N x R x SP	140.51	4	35.13	1.03
R x SP x Subj. w gps.	4,207.40	124	33.93	

Summary Table for Simple Main effects (R x SP)

Source	SS	df	MS	F
R at SP_1	159.33	2	79.66	1.81
R at SP_2	2,986.92	2	1,493.46	34.04**
R at SP_3	2,475.32	2	1,237.66	28.21**
Error		186	43.87	
SP at R_1	2,255.63	2	1,127.81	10.04**
SP at R_2	5,063.29	2	2,531.64	22.54**
SP at R_3	8,400.00	2	4,200.00	37.40**
Error		186	112.31	

(5) NN v. QQ

Source	SS	df	MS	F
Between subjects	48,942.03	45		
N	1,794.81	1	1,794.81	1.67
Subj. w gps.	47,147.22	44	1,071.53	
Within subjects	73,373.84	368		
R	5,078.40	2	2,539.20	37.26**
N x R	80.19	2	40.09	<1
R x Subj. w gps.	5,996.57	88	68.14	
SP	26,859.96	2	13,429.98	43.37**
N x SP	1,268.11	2	634.05	2.05
SP x Subj. w gps.	27,247.77	88	309.63	
R x SP	931.85	4	232.96	7.18**
N x R x SP	200.49	4	50.12	1.54
R x SP x Subj. w gps.	5,710.50	176	32.45	

Summary Table for Simple Main Effects (R x SP)

Source	SS	df	MS	F
R at SP_1	270.82	2	135.41	3.05*
R at SP_2	3,105.06	2	1,552.53	35.01**
R at SP_3	2,634.36	2	1,317.18	29.70**
Error		264	44.35	
SP at R_1	5,832.88	2	2,916.44	23.36**
SP at R_2	8,212.01	2	4,106.00	32.89**
SP at R_3	13,746.91	2	6,873.45	55.06**
Error		264	124.84	

QN v. QQ comparison

The main effects of rate ($F=24.64$; df 2,62; $p < .01$) and serial position ($F=23.03$; df 2,62; $p < .01$) again reached significance. Comparisons between means for the former effect revealed that significantly fewer digits were recalled at the fastest presentation rate than at the rate of 2/S ($q=6.48$; df 3,62; $p < .01$) or 1/S ($q=9.75$; df 3,62; $p < .01$). For the main effect of serial position, comparisons between means showed that significantly more digits were recalled from positions 1-3 than from positions 4-6 ($q=7.40$; df 3,62; $p < .01$) or from positions 7-9 ($q=9.01$; df 3,62; $p < .01$). The interaction R x SP also reached significance ($F=7.27$; df 4,124; $p < .01$) and was analysed further for simple main effects, the summary table of which is given in Table 45.

NN v. QN comparison

The main effects of rate ($F=39.37$; df 2,62; $p < .01$) and serial position ($F=17.62$; df 2,62; $p < .01$) both reached significance. Comparisons between means for the main effect of rate revealed that significantly more digits were recalled at the presentation rate of 1/S than at 2/S ($q=4.90$; df 3,62; $p < .01$) or at 3/S ($q=12.52$; df 3,62; $p < .01$). More digits were also recalled at the presentation rate of 2/S than at the rate of 3/S ($q=7.62$; df 3,62; $p < .01$). Comparisons between means for the main effect of serial position revealed that significantly more digits were recalled from positions 1-3 than from positions 4-6 ($q=7.18$; df 3,62; $p < .01$) or from positions 7-9 ($q=7.35$; df 3,62; $p < .01$). The significant interaction between R and SP ($F = 8.59$; df 4,124; $p < .01$) was analysed further for simple main effects and the summary table for this is given in Table 45.

NN v. NQ comparison

The main effects of rate (F=35.40; df 2,62; $p < .01$) and serial position (F=27.15; df 2,62; $p < .01$) reached significance. Comparisons between means for the main effect of rate revealed that significantly more digits were recalled at the presentation rate of 1/S than at 2/S (q=5.13; df 3,62; $p < .01$) or 3/S (q=11.91; df 3,62; $p < .01$). Also more digits were recalled at the rate of 2/S than at 3/S (q=6.78; df 3,62; $p < .01$). Comparisons between means for the main effect of serial position showed that significantly more digits were recalled from positions 1-3 than from positions 4-6 (q=7.74; df 3,62; $p < .01$) or positions 7-9 (q=9.94; df 3.62; $p < .01$). The significant interaction, R x SP, (F=8.16; df 4,124; $p < .01$) was analysed further for simple main effects and the summary table for this is given in Table 45.

NN v. QQ comparison

The main effects of rate (F=37.26; df 2,88; $p < .01$) and serial position (F-43.37; df 2,88; $p < .01$) again reached significance. Comparisons between means for the main effect of rate revealed that significantly fewer digits were recalled at the presentation rate of 3/S than at the rate of 2/S (q=6.32; df 3,88; $p < .01$) or at the rate of 1/S (q=9.34; df 3,88; $p < .01$). Comparisons between means for the main effect of serial position showed that significantly more digits were recalled from positions 1-3 than from positions 4-6 (q=7.86; df 3,88; $p < .01$) or from positions 7-9 (q=9.67; df 3,88; $p < .01$). The significant interaction, R x SP (F=7.18; df 4,176;

$p < .01$) was analysed further for simple main effects and the summary table for this analysis is given in Table 45.

Spearman rank correlation coefficients were also computed for the total number of digits correct x number written down order 1-9 for each N condition and these are given in Table 46.

7.3 Discussion

The overall results of the two digits/second presentation rate are generally very similar to those of Experiment 4, although the mean percentage correct for Trial 1 data tends to be rather higher in three conditions (NN, NQ and QQ). Similarly, the mean percentage correct for the main block of trials tends to be very close in the two experiments with the exception that the QN condition appears to be rather lower. The percentage written down in the order 1-9 and the correlations between the number written down in the order 1-9 and the total number of digits correct are also very similar in the two experiments (apart from percentage order 1-9 in QQ and QN). For the main block of trials, there is no difference between overall performance in NQ and QQ as would be expected from the results of Experiment 4. However, the tendency for different SP curves in NQ and QQ obtained in Experiment 4 was not evident in the present experiment, since almost identical curves were obtained in NQ and QQ. The reasons for this are not clear although one or two differences between the experiments could be noted. Firstly, there were more trials overall in the present experiment (75 compared with 50) although only 25 of these

Table 46

Spearman rank correlation coefficient for total number of digits correct x number order 1-9

	NN	NQ	QN	QQ
Rate 1/S	-0.45	0.05	-0.49	-0.25
Rate 2/S	-0.24	-0.32	-0.64	0.12
Rate 3/S	-0.03	-0.21	-0.20	0.25
	n=23	n=10	n=10	n=23

Table 47

% Correct and % Written Down Order 1-9 in Experiment 4 and Experiment 5 at 2/S Rate

	NN	NQ	QN	QQ
% correct (Trial 1)				
Experiment 4	55.5	40.0	52.2	35.5
Experiment 5 (2/S)	59.4	52.2	50.0	50.2
% Correct (main trials)				
Experiment 4	63.0	58.9	72.2	57.3
Experiment 5 (2/S)	62.7	57.9	65.1	57.9
% Order 1-9				
Experiment 4	70.4	61.8	58.4	40.4
Experiment 5 (2/S)	69.6	65.6	38.0	60.0

were presented at the rate of 2/second. Secondly, whereas in Experiment 4, subjects received the whole block of trials at one presentation rate and therefore knew what rate to anticipate, this was not so in the present experiment. Although there was a pattern in the order of presentation rates (e.g. abccbaabc etc.) subjects apparently did not realise this, according to their comments at the end of the experiment and therefore they did not know what rate to anticipate for a particular stimulus list. If subjects wished to organise or rehearse their material differently for different presentation rates, this would have been very difficult in the present experiment. Murdock (1974) has suggested that for free recall if conditions (e.g. list length) change from trial to trial one might continue to maintain subjects at a naive level of performance. Thus in the present experiment, if changing presentation rate from trial to trial results in subjects remaining at a naive level, this could possibly account for the discrepancy between the two sets of results.

The results from all four N conditions suggest that recall in N tends to result in better performance than recall in Q, although none of the comparisons reached significance. If recall in N results in subjects adopting the reconstruction strategy rather than the scanning operation adopted in Q, as suggested in Experiments 4 and 4A, then the present results suggest that the reconstruction strategy tends to result in slightly better performance, which is in agreement with the results of Experiment 4 and 4A. The results for the two other presentation rates are similar to those for the 2/second rate, with recall in N tending to result in slightly better performance than recall in Q.

The effects of N during input appear to be somewhat variable. When recalling in Q, performance in NQ tends to be slightly better than that in QQ at the slowest presentation rate, whereas there is virtually no difference between the conditions at the other rates. At the 3/second rate it is assumed that in both conditions subjects have to process at less deep levels because of the limited time available. If, as was suggested in the previous experiments, N during input facilitates phonemic coding then it would be expected that performance in NQ would be better than that in QQ. However, this was not the case.

When recalling in noise, noise during input tends to result in slightly worse performance than that obtained with Q during input. This was expected from the results of the previous experiments.

Considering the effects of presentation rate, decreasing the rate resulted in increasing ascuracy, a finding in agreement with those of Pollack (Pollack et al., 1959; Pollack and Johnson, 1963), Mackworth (1962c) and Murdock (1960). However, since other studies (Fraser, 1958; Conrad and Hille, 1958) have reported the opposite finding of increased accuracy with increasing presentation rate, it was proposed by Posner (1964) that a possible factor in the conflicting results of presentation rate effects is the order of recall of subjects. He tested this and found that when subjects recalled in the order 1-4, 5-8 performance was better at faster rates, whereas when subjects recalled 5-8 then 1-4, no differences in rate were obtained. Posner interpreted his results as supporting a decay factor in immediate memory. If recalling in the order 1-4, 5-8 results in better performance at faster rates, this could suggest that recalling in order is a more appropriate strategy after faster presentation rates than after slower ones. If this is the case, the correlation between the order 1-9 and the total number of digits correct in the control condition of the present experiment would be expected to be greater at the faster presentation rates. From Table 47 it can be seen that although the correlations are small and negative, nevertheless there is a tendency in this direction.

However, Posner's hypothesis does not completely account for the effects of rate on recall accuracy as demonstrated in the following studies. Mackworth (1962c) used 'free' and serial recall and found accuracy for the slow presentation rates to be superior in both conditions. Similarly Pollack et al. (1959) showed running memory span to be better at slow rates with recall allowed in any order. Consequently it was suggested by Hockey (1973) that while Posner was right to point out that transformations of order in recall may well be related to rehearsal processes, it is not clear what differences in strategies during presentation play in the effect of rate. Thus Hockey (1973) examined the effects of rate on recall when subjects are told to consistently use strategies involving either active organisation (grouping and rehearsal) or passive reception of items (no rehearsal or grouping). The modes of attention, active and passive, were distinguished following the distinction made by Aaronson (1968). The results demonstrated clear and reliable differences between strategies in the effects of rate. Active processing was best at the rate of 1/S and deteriorated monotonically with increases in rate, while passive processing showed the opposite trend, improving from 1/sec to 3/sec.

It would thus appear that some of the discrepancies in the presentation rate data could possibly be due to different processing strategies employed by subjects. The observed increased accuracy with decreasing presentation rate in the present experiment in all four noise conditions may thus suggest that subjects are employing an active rather than a passive processing strategy, and this occurs whether or not N is present during input.

It was suggested in the introduction that faster presentation rates would result in less deep levels of processing, i.e. phonemic coding, whereas slower rates would allow subjects to process more deeply and since the results of the previous experiments suggested that N facilitates phonemic coding but impairs deeper levels of processing, a N x presentation rate interaction was considered a possibility, but this was not observed. It has already been noted that the presentation rate changed from trial to trial and that this may have affected subjects encoding strategies. However, the lack of an interaction between N x presentation rate would seem to be consistent with the results of Conrad, Baddeley and Hull (1966) and Laughery and Pinkus (1966). Both studies examined the effects of presentation rate on acoustically similar and dissimilar lists of consonants. If increased presentation rate results in phonemic coding to a greater extent than slower rates an interaction between presentation rate and acoustic similarity would be expected, but this did not occur. A common factor in the two studies above and the present experiment is that all three have used relatively short strings of either consonants or digits i.e. rather meaningless material and it is doubtful whether deeper levels of processing (particularly semantic processing) are possible with such material. With longer lists of meaningful words, Shulman, (1970) obtained a significant interaction between type of encoding and presentation rate, with slower presentation rates resulting in an increased probability of encoding a word semantically.

Craik and Lockhart (1972) suggested that memory performance depends on the depth to which the stimulus is analysed. This formulation implies that the stimulus is processed through a fixed series of analysers from structural to semantic, and that the system stops processing the stimulus once the analysis relevant to the task has been carried out. Craik and Tulving (1975) consider these original notions to be unsatisfactory in a number of ways. For example, the postulated analyses cannot lie on a continuum since structural analyses do not shade into semantic analyses, and a modified view of 'domains' of encoding (Sutherland, 1972) was suggested by Lockhart, Craik and Jacoby (1976). They further suggest that 'greater depth' may refer to two somewhat distinct changes in processing. First, the domains themselves may be thought of as a hierarchical organisation proceeding from shallow, structural domains to deep, semantic domains. Second, at one depth in this sense, the stimulus may be further analysed or elaborated by carrying out additional operations within one qualitatively coherent domain. When the stimulus material to be remembered consists of relatively short strings of consonants or digits, it is possible that encoding only occurs in the physical and phonemic domains. However, within each of these domains the stimulus may be elaborated further and although the form of this further elaboration is not specified in more detail by Lockhart et al. a feasible possibility could be the grouping or chunking of items. Thus in the present experiment stimulus encoding may have been at the phonemic level for all presentation rates, but at the slowest rate, more grouping or chunking of the input is possible and the better performance associated with decreasing presentation rate suggests that deeper levels of processing (i.e. more grouping or chunking) within one domain result in improved performance. The comparison between the NQ and QQ conditions at the slowest presentation rate (when presumably more time is available for grouping) suggests that noise during input has a tendency to improve performance when recall is undertaken in quiet and this could be due to N tending to exert a beneficial effect on the grouping or chunking of items.

One interaction in the present experiment which did reach significance in all of the separate analyses for the main blocks of trials, was that of rate x serial position, with rate affecting later items in the list rather than earlier ones. This latter finding was unexpected since presentation rate is not one of the variables noted to affect recency. However, the present experiment is not alone in obtaining an effect of rate on later items (Norman, 1966; Buschke and Lim, 1967) and indeed, according to Murdock (1975) his nesting model of serial order effects would predict that errors in a serial order memory paradigm should not be dependent upon the rate at which the material is presented but he also states "the fact that a slower rate does seem to help visual memory span may reflect auditory elaboration and, as such, should be localised in the recency effect" (p. 298). Although it is realised that the present experiment did not enforce subjects to employ a serial order of report, nevertheless the majority of subjects responses were reported serially and furthermore the recall test was merely one of order since all the digits 1-9 appeared only once in any 9-digit string.

7.4 Conclusion

The results of the present experiment appear to be fairly similar to those of Experiment 4, but not as pronounced, with recall during noise tending to result in better performance than that during recalling in Q. The expected interaction between N and presentation rate was not obtained and it was suggested that the type of material employed in the present experiment in probably not conducive to deeper levels of coding in the sense of proceeding to a different domain. A slight tendency for noise during input compared with Q to improve performance when recall is in Q was observed for the slower presentation rate and it was suggested that a possible reason for this may be that N facilitates deeper encoding within one domain, but only when sufficient time is available. When recall is in N, there is very little difference between N and Q conditions at input, particularly at faster rates.

CHAPTER 8

NOISE AND PRESENTATION TYPE

Tulving (1968) distinguishes between two types of organisation: secondary organisation which involves the semantic aspects of items and primary organisation which describes strategies based on relations such as position in the list, or grouping of items in space or time. For example subjects are able to recall more random digits if they rehearse them in groups of three rather than attending to one at a time or trying to rehearse groups of four or more. Rhythmic grouping by the subject forms a substantial part of the recoding process as described by Neisser (1967). Recoding or organisation into what Miller (1956) called 'chunks' is necessary in order to overcome the capacity limitations inherent in the human information processing system and rhythmic grouping is perhaps the simple form of organisation and rhythmic grouping has been shown to affect short-term memory (Neisser, 1969). However, another type of primary organisation is that based on spatial attributes (Underwood, 1967).

A statement considered to be made by various authors, according to Hermelin and O'Connor (1973) is that while visual information tends to be organised in spatial terms, auditory stimuli become temporally ordered in memory. However, temporal ordering has been found not only with auditory but also with visually presented items (Murdock, 1969; O'Connor and Hermelin, 1972). Nevertheless Bryden (1967) found that in contrast with auditorily presented items, visual material, when presented simultaneously tended to be spatially organised, although temporal ordering predominates if successive presentation with inter-stimulus intervals of 300ms is used. Recall after simultaneous v. serial visual presentation has not received much attention, although a few studies have suggested that simultaneous presentation results in superior performance (Crowder, 1966; Mackworth, 1962 a, b). Mackworth cited visual factors (strength of visual image and memory trace) as the most likely reason for her results. Work by Mayzner and his co-workers (Mayzner and Gabriel, 1963; Mayzner and Gabriel, 1964; Mayzner and Adler, 1965) suggests that an important factor in simultaneous visual presentation is that of organisation or 'chunking'. Subjects received the same items but organised in different ways. Five different groups of subjects received a set of 12 digits for a period of 6 seconds, but each group received them in a differently organised array i.e. 12 lines (1 digit per line), 6 lines (2 digits per line) etc. Their results showed a systematic increase in retention from 12 lines to 2 lines and a 'chunking' model was employed to account for these effects of stimulus organisation on retention. Obviously, much more work is required before any comment can be made concerning the similarity or otherwise between temporal grouping and spatial grouping.

Recent work, however, suggests that there may be differences in the type of encoding employed in organising simultaneously presented rather than serially presented items. Adams, Thorsheim and McIntyre (1969) observed that the usual interference effect obtained with acoustically similar items presented sequentially for immediate recall, did not occur when items were presented simultaneously for immediate recall, possibly suggesting that phonemic encoding does not appear to play an important part in spatial organisation. In experiments by O'Connor and Hermelin (1972) deaf and hearing children were shown three successively displayed digits in three windows in such a way that the left to right order never corresponded to the temporal sequential order of presentation. In one study the children were asked to recognise the order of the previously presented digits. After an initial presentation in which temporal and spatial orders were always incongruent, the children were required to make a forced recognition choice between cards showing either the temporal or the left-to-right sequence. Hearing children only recognised the temporal first-to-last sequence while many deaf children recognised the spatial left-to-right order, regardless of the temporal sequence.

In previous experiments (Experiments 1, 2, 3 and 4A) it has been suggested that noise during the input of a list of words results in more efficient phonemic coding but less efficient semantic coding and this shows itself in better recency but slightly worse primacy when recall is undertaken in quiet conditions. Similar effects were noted with the presentation of digits presented at a constant rate, although it was suggested that for shorter lists of less meaningful material it would be unlikely that subjects would adopt deeper levels of processing than phonemic encoding, and therefore the tendency for better performance in the NQ conditions compared with the QQ conditions in Experiment 4 was interpreted as improved phonemic encoding in N. If phonemic encoding is not as important for simultaneously presented items as for serially presented ones then the tendency for improved performance in NQ compared with QQ would not be expected. It was therefore considered worthwhile to examine the effects of N upon performance of a simultaneously presented memory task. In order to compare the possible differential effects of N on the two types of presentation, the same stimulus material as that in Experiment 4 was employed i.e. 9-digit sequences.

8.1 Method

8.1.1 Subjects

Sixty sixth-formers, 30 males and 30 females, aged between 16 and 18 years participated in the experiment and were paid for their services. Subjects were randomly allocated to one of four experimental conditions; noise during presentation of stimuli and recall (NN); noise during presentation of stimuli but not during recall (NQ); quiet during presentation and noise during recall (QN); quiet during presentation and recall (QQ). Twenty subjects, 10 males and 10 females were assigned to both the NN and QQ conditions and 10 subjects, 5 males and 5 females were assigned to both the NQ and QN conditions. The subjects were tested individually.

8.1.2 Apparatus

A list of 55 9-digit sequences was compiled using random number tables with the restriction that no digit would appear more than once in a particular sequence; zero was not used. Fifty-five 36x24 cm. slides were prepared each containing one of these 9-digit sequences in the centre of the slide.

As in Experiments 1-3, a Kodak Carousel projector was used to project the slides on to a plain white wall which was at a distance of 3metres from the projector lens. The projector was connected to an electronic time interval control unit which was set to present the slides at fixed intervals.

The same noise tape as in previous experiments was used and once again it was played on a Ferrograph recorder. As in Experiments 4 and 5, the noise was presented to the subject over head-phones. The volume control of the tape-recorder was adjusted until the noise level at the central point of the head-phone was either 90dB or 65dB.

8.1.3 Procedure

The subject was seated at a table facing the wall at a distance of 2.5 metres from it. He was instructed that when the warning light, which was placed on the table, was extinguished he would be shown a slide containing 9 digits. When the slide disappeared he was to write down the digits on specially prepared response sheets containing rows of 9 boxes. The subject was required to put each digit in the sequence in the box corresponding to its position on the slide. As before, if the subject was unsure of a response he must guess rather than leave any of the boxes blank. As in the previous experiments the subject was free to fill in the boxes in any order, although the order of recall was recorded in the same manner as in Experiments 4 and 5, but once again the subject was not informed of this.

After the experimenter had ensured that the instructions had been understood, the experiment began. Each 9-digit sequence was presented for $4\frac{1}{2}$ seconds. The subject was required to complete his recall in 15 seconds, but after 13 seconds of this period the warning light came on for 2 seconds to indicate to the subject that the next sequence was about to start. There were 20 different orders of presentation of the slides but in each it was ensured that no digit appeared in the same position in two successive slides. Each subject, therefore, in a particular condition received the 55 slides in a different order.

Subjects in the NN group received noise at a level of 90dB throughout the experiment and those in the QQ group, at a level of 65dB throughout. However, subjects in the NQ group received noise at a level of 90dB during the presentation of the digits and at a level of 65dB during recall, while subjects in the QN group received these conditions in reverse order.

As in the previous experiments, care was taken to control for possible TOD effects.

8.2 Results

The analysis of the results is divided into three sections: (i) the analysis of the results of Trial 1 only; (ii) the analysis of the results of trials 6-55; (iii) a comparison between the results of Experiment 4 (serial presentation) with the present experiment (simultaneous presentation). In the first two, the analysis is undertaken by step-wise comparisons between two N conditions at a time, although, the results of analyses involving all four N conditions are given in Appendix 6.

(i) Results of Trial 1 only

Recall performance was assessed by considering the number of digits recorded in their correct serial position and Table 48 shows the mean total percentage correct in each N condition. Separate 2x3 (N condition; S positions 1-3; 4-6; 7-9) analyses of variance having a repeated measure on the second factor were computed for two N conditions at a time and the summary tables for these are given in Table 49.

NQ v. QQ comparison

The main effect of serial position reached significance (F=5.96; df 2,56; $p < .01$) and comparisons between means revealed that significantly more digits were recalled from positions 1-3 than from positions 7-9 (q=4.82; df 3,56; $p < .01$). The significant interaction N x SP was analysed further for simple main effects and the summary table for this is given in Table 49 from which it can be seen that the effects of noise are only significant on the recency part of the serial position curve.

QN v. QQ comparison

Only the main effect of serial position reached significance (F=22.88; df 2,56; $p < .01$) and comparisons between means revealed that significantly more digits were recalled from positions 1-3 than from positions 4-6 (q=3.56; df 3,56; $p < .05$) or from positions 7-9 (q=9.5; df 3,56; $p < .01$). Similarly more digits were recalled from positions 4-6 than from positions 7-9 (q=5.94; df 3,56; $p < .01$).

NN v. QN comparison

The main effect of serial position reached significance (F=19.59; df 2,56; $p < .01$) and comparisons between means showed that significantly more digits were recalled from positions 1-3 than from positions 4-6

Table 48

Mean % Correct in each N Condition

	NN	NQ	QN	QQ
Trial 1	77.2	77.8	63.3	75.0
Trials 6-55	83.5	77.0	70.5	76.4

Mean % Written Down Order 1-9

NN	NQ	QN	QQ
88	81.4	94.4	87.2

Table 49

Anova - Noise x Serial position (Trial 1)

(1) NQ v. QQ

Source	SS	df	MS	F
Noise (N)	0.13	1	0.13	<1
Subj. w gps.	37.25	28	1.33	
Serial position (SP)	9.06	2	4.53	5.96**
N x SP	5.20	2	2.60	3.42*
SP x Subj. w gps.	42.50	56	0.76	

Summary Table for Simple Main Effects (N x SP)

Source	SS	df	MS	F
N at SP_1	0.40	1	0.40	<1
N at SP_2	0.67	1	0.67	<1
N at SP_3	4.26	1	4.26	4.48*
Error		84	0.95	
SP at N_1	1.73	2	0.86	1.13
SP at N_2	12.53	2	6.26	8.24**
Error		56	0.76	

(2) QN v. QQ comparison

Source	SS	df	MS	F
N	2.53	1	2.53	2.11
Subj. w gps.	33.59	28	1.20	
SP	31.59	2	15.79	22.88**
N x SP	0.40	2	0.20	< 1
SP x Subj. w gps.	38.50	56	0.69	

(3) NN v. QN comparison

Source	SS	df	MS	F
N	3.46	1	3.46	2.29
Subj. w gps.	42.35	28	1.51	
SP	19.99	2	9.99	19.59**
N x SP	3.46	2	1.73	3.39*
SP x Subj. w gps.	28.70	56	0.51	

Summary Table for Simple Main Effects (N x SP)

Source	SS	df	MS	F
N at SP_1	0.03	1	0.03	< 1
N at SP_2	0.27	1	0.27	< 1
N at SP_3	6.66	1	6.66	7.93**
Error		84	0.84	
SP at N_1	4.00	2	2.00	3.92*
SP at N_2	19.46	2	9.73	19.08**
Error		56	0.51	

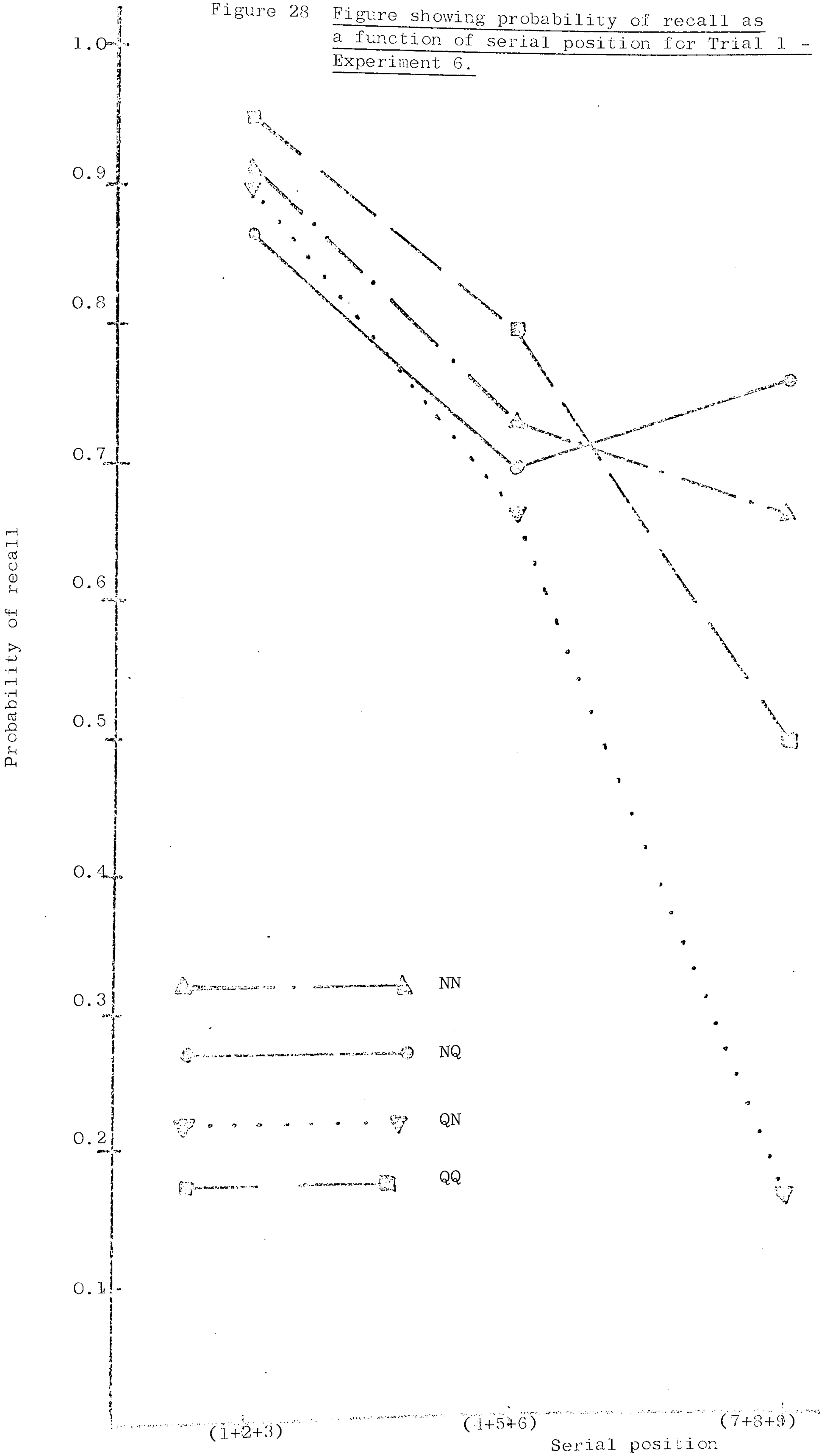
(4) NN v. NQ comparison

Source	SS	df	MS	F
N	0.01	1	0.01	<1
Subj. w gps.	45.65	28	1.63	
SP	4.80	2	2.40	4.14*
N x SP	0.93	2	0.46	1
SP x Subj. w gps.	32.70	56	0.58	

(5) NN v. QQ comparison

Source	SS	df	MS	F
Between subjects	47.04			
N	0.14	1	0.14	<1
Subj. w gps.	46.90	38	1.23	
Within subjects	77.33			
SP	22.07	2	11.03	15.98**
N x SP	2.86	2	1.43	2.07
SP x Subj. w gps.	52.40	76	0.69	

Figure 28 Figure showing probability of recall as a function of serial position for Trial 1 - Experiment 6.



($q=4.43$; df 3,56; $p < .01$) or from positions 7-9 ($q=8.71$; df 3,56; $p < .01$). Similarly, more digits were recalled from positions 4-6 than from positions 7-9 ($q=4.28$; df 3,56; $p < .05$). The significant interaction N x SP was analysed further for simple main effects and the summary table for this is given in Table 49 from which it can be seen that the effects of N are only significant on serial positions 7-9.

NN v. NQ comparison

Only the main effect of serial position reached significance ($F=4.14$; df 2,56; $p < .05$) and comparisons between means revealed that significantly more digits were recalled from positions 1-3 than from positions 4-6 ($q=3.47$; df 3,56; $p < .01$) or from positions 7-9 ($q=3.47$; df 3,56; $p < .01$).

NN v. QQ comparison

Only the main effect of serial position reached significance ($F=15.98$; df 2,76; $p < .01$) and comparisons between means revealed that significantly more digits were recalled from positions 1-3 than from positions 4-6 ($q=3.85$; df 3,76; $p < .01$) or from positions 7-9 ($q=8.08$; df 3,76; $p < .01$). Similarly more digits were recalled from positions 4-6 than from positions 7-9 ($q=4.23$; df 3,76; $p < .05$).

(ii) Results of Trials 6-55

Recall performance was again assessed by considering the total number of digits recorded in the correct serial position and the mean percentage correct in each N condition can be seen in Table 48 , as can also the mean percentage written down in the order 1-9. Separate 2x5 (N condition; Blocks of 10 trials) analyses of variance with repeated measures on the second factor were carried out on the recall order data for 2N conditions at a time and the summary tables for these are shown in Table 50.

<u>NQ v. QQ comparison</u>

Only the main effect of blocks reached significance ($F=2.67$; df 4,112; $p < .05$) and comparisons between means revealed that significantly more responses were written down in the order 1-9 in the last ten trials than in the first ten trials ($q=3.96$; df 5,112; p .05).

<u>QN v. QQ comparison</u>

No effects reached significance.

<u>NN v. QN comparison</u>

No effects reached significance.

<u>NN v. NQ comparison</u>

The interaction N x B reached significance ($F=2.57$; df 4,112; $p < .05$) and this was analysed further for simple main effects. The summary table of this analysis is given in Table 50 from which it can be seen that the effects of N are only significant during the first block of 10 trials ($F=4.12$; df 1,140; $p < .05$) when more trials are recorded in the order 1-9 in NN than in NQ.

<u>NN v. QQ comparison</u>

Only the interaction N x B reached significance ($F=4.14$; df 4,312; $p < .01$) and this was analysed further for simple main effects. The

Table 50

Anova Noise x Blocks (for number order 1-9)

NQ v. QQ comparison

Source	SS	df	MS	F
Noise (N)	11.20	1	11.20	< 1
Subj. w gps.	467.38	28	16.69	
Blocks (B)	16.13	4	4.03	2.67*
N x B	7.46	4	1.86	1.23
B x Subj. w gps.	169.42	112	1.51	

QN v. QQ comparison

Source	SS	df	MS	F
N	17.33	1	17.33	1.19
Subj. w gps.	406.88	28	14.53	
B	2.67	4	0.67	< 1
N x B	4.40	4	1.10	1.06
B x Subj. w gps.	116.62	112	1.04	

NN v. QN comparison

Source	SS	df	MS	F
N	13.73	1	13.73	< 1
Subj. w gps.	587.52	28	20.98	
B	5.20	4	1.30	1.23
N x B	1.47	4	0.37	< 1
B x Subj. w gps.	118.38	112	1.06	

NN v. NQ comparison

Source	SS	df	MS	F
N	14.53	1	14.53	< 1
Subj. w gps.	648.02	28	23.14	
B	7.46	4	1.86	1.21
N x B	15.73	4	3.93	2.57*
B x Subj. w gps.	171.18	112	1.53	

Summary Table for Simple Main Effects (N x B)

Source	SS	df	MS	F
N at b_1	24.13	1	24.13	4.12*
N at b_2	0.67	1	0.67	< 1
N at b_3	3.33	1	3.33	< 1
N at b_4	2.00	1	2.00	< 1
N at b_5	0.13	1	0.13	< 1
Error		140	5.85	
b at N_1	4.40	4	1.10	< 1
b at N_2	18.79	4	4.70	3.07*
Error		112	1.53	

NN v. QQ comparison

Source	SS	df	MS	F
Between subjects	889.28			
N	0.32	1	0.32	< 1
Subj. w gps.	888.96	78	11.40	
Within subjects	193.20			
B	4.52	4	1.13	1.98
N x B	9.44	4	2.36	4.14**
B x Subj. w gps.	179.24	312	0.57	

Summary Table for Simple Main Effects (N x B)

Source	SS	df	MS	F
N at B_1	3.60	1	3.60	1.31
N at B_2	1.60	1	1.60	< 1
N at B_3	0.63	1	0.63	< 1
N at B_4	0.90	1	0.90	< 1
N at B_5	3.03	1	3.03	1.10
Error		390	2.74	
B at N_1	6.70	4	1.67	2.93*
B at N_2	7.26	4	1.81	3.18*
Error		312	0.57	

summary table for this is given in Table 50 from which it can bee seen that the effects of N do not reach significance at any of the blocks of 10 trials, although a tendency was noted for more responses to be in the order 1-9 in NN than in QQ during the first 10 trials while the reverse was the case during the last 10 trials.

Separate 2 x 5 x 3 (N condition; Blocks of 10 trials; serial positions 1-3; 4-6; 7-9) analyses of variance with repeated measures on the second and third factors were carried out on the number of digits correct for 2N conditions at a time and the summary tables for these are given in Table 51.

NQ v. QQ comparison

Only the main effect of serial position reached significance ($F=50.91$; df 2,56; $p < .01$) and comparisons between means revealed that significantly more digits were recalled from positions 1-3 than from positions 4-6 ($q=9.17$; df 3,56; $p < .01$) or from positions 7-9 ($q=14.20$; df 3,56; $p < .01$). Similarly more digits were recalled from positions 4-6 than from positions 7-9 ($q=5.04$; df 3,56; $p < .01$).

QN v. QQ comparison

Both the main effect of blocks ($F=3.40$; df 4,112; $p < .05$) and serial position ($F=92.04$; df 2,56; $p < .01$) reached significance. Comparisons between means for the main effect of blocks revealed that significantly more digits were recalled in the fourth block of 10 trials than in the first block ($q=4.91$; df 5,112; $p < .01$) but all other comparisons failed to reach significance. Comparisons between means for

Table 51

Anova Noise x Blocks x Serial position

NQ v. QQ comparison

Source	SS	df	MS	F
Noise (N)	3.60	1	3.60	< 1
Subj. w gps.	5,331.04	28	190.39	
Blocks (B)	49.05	4	12.26	< 1
N x B	19.73	4	4.93	< 1
B x Subj. w gps.	1,547.26	112	13.81	
Serial position (SP)	4,031.39	2	2,015.69	50.91**
N x SP	139.30	2	69.65	1.76
SP x Subj. w gps.	2,217.00	56	39.59	
B x SP	67.18	8	8.40	1.14
N x B x SP	18.53	8	2.32	< 1
B x SP x Subj. w gps.	1,647.70	224	7.35	

QN v. QQ comparison

Source	SS	df	MS	F
N	312.05	1	312.05	1.98
Subj. w gps.	4,418.09	28	157.79	
B	213.28	4	53.32	3.40*
N x B	122.77	4	30.69	1.96
B x Subj. w gps.	1,753.51	112	15.66	
SP	8,163.69	2	4,081.84	92.04**
N x SP	263.13	2	131.56	2.97+
SP x Subj. w gps.	2,483.45	56	44.35	
B x SP	89.71	8	11.21	1.50
N x B x SP	69.18	8	8.65	1.16
B x SP x Subj. w gps.	1,676.85	224	7.48	

NN v. QN comparison

Source	SS	df	MS	F
N	1,520.55	1	1,520.55	13.40**
Subj. w gps.	3,178.10	28		
B	297.92	4	74.48	5.97**
N x B	80.65	4	20.16	1.[illegible]
B x Subj. w gps.	1,396.34	112	12.47	
SP	6,288.03	2	3,144.01	107.27**
N x SP	721.02	2	360.51	12.30**
SP x Subj. w gps.	1,641.14	56	29.31	
B x SP	109.97	8	13.75	2.59*
N x B x SP	80.11	8	10.01	1.89+
B x SP x Subj. w gps.	1,188.12	224	5.30	

Summary Table for Simple Main Effects (N x SP)

Source	SS	df	MS	F
N at SP_1	1.73	1	1.73	< 1
N at SP_2	796.87	1	796.87	13.89**
N at SP_3	1,442.84	1	1,442.84	24.15**
Error		84	57.37	
SP at N_1	1,380.19	2	690.09	23.54**
SP at N_2	5,628.86	2	2,814.43	96.02**
Error		56	29.31	

Summary Table for Simple Main Effects (B x SP)

Source	SS	df	MS	F
B at SP_1	25.46	4	6.36	< 1
B at SP_2	231.01	4	57.75	7.51**
B at SP_3	151.43	4	37.86	4.92**
Error		336	7.69	
SP at B_1	1,501.36	2	750.68	74.32**
SP at B_2	1,740.63	2	870.31	86.17**
SP at B_3	1,078.80	2	539.40	53.40**
SP at B_4	986.15	2	493.07	48.82**
SP at B_5	1,091.06	2	545.53	54.01**
Error		280	10.10	

NN v. NQ comparison

Source	SS	df	MS	F
N	378.84	1	378.84	2.59
Subj. w gps.	4,091.05	28	146.11	
B	105.71	4	26.43	2.49+
N x B	5.60	4	1.40	< 1
B x Subj. w gps.	1,190.09	112	10.62	
SP	2,749.18	2	1,374.59	55.99**
N x SP	3.73	2	1.86	< 1
SP x Subj. w gps.	1,374.69	56	24.55	
B x SP	53.45	8	6.68	1.29
N x B x SP	63.45	8	7.93	1.53
B x SP x Subj. w gps.	1,158.97	224	5.17	

NN v. QQ comparison

Source	SS	df	MS	F
Between subjects	6,051.37	39		
N	682.68	1	682.68	4.83*
Subj. w gps.	5,368.69	38	141.28	
Within subjects	13,042.54	560		
B	79.09	4	19.77	1.55
N x B	42.30	4	10.57	< 1
B x Subj. w gps.	1,935.15	152	12.73	
SP	6,079.81	2	3,039.90	83.51**
N x SP	189.08	2	94.54	2.60+
SP x Subj. w gps.	2,766.45	76	36.40	
B x SP	48.61	8	6.08	< 1
N x B x SP	50.94	8	6.37	1.04
B x SP x Subj. w gps.	1,851.11	304	6.09	

the main effect of serial position revealed that significantly more digits were recalled from positions 1-3 than from positions 4-6 (q=12.26; df 3,56; $p < .01$) or from positions 7-9 (q=18.79; df 3,56; $p < .01$). Similarly more digits were recalled from positions 4-6 than from positions 7-9 (q=6.53; df 3,56; $p < .01$). The interaction N x SP approached significance (F=2.97; df 2,56; $p < .10$) with N during recall tending to result in worse performance during later serial positions (see Figure 29).

<u>NN v. QN comparison</u>

All three main effects - noise (F=13.40; df 1,28; $p < .01$); blocks (F=5.97; df 4,112; $p < .01$) and serial position (F=107.27; df 2,56; $p < .01$) - reached significance. Performance in NN was significantly better than that in QN. Comparisons between means for the main effect of blocks revealed that significantly fewer digits were recalled in the first block of 10 trials than in the third block (q=4.64; df 5,112; $p < .05$) or the fourth block (q=6.31; df 5,112; $p < .01$). Similarly, fewer digits were recalled in the second block than in the fourth block (q=4.56; df 5,112; $p < .05$). All other comparisons failed to reach significance. Comparisons between means for the main effect of serial position revealed that significantly more digits were recalled from positions 1-3 than from positions 4-6 (q=13.64; df 3,56; $p < .01$) or from positions 7-9 (q=20.25; df 3,56; $p < .01$). More digits were also recalled from positions 4-6 than from positions 7-9 (q=6.62; df 3,56; $p < .01$). The significant interaction N x SP was analysed further for simple main effects and the summary for this is given in Table 51 . The effects of noise are significant at positions 4-6

(F=13.89; df 1,84; p < .01) and positions 7-9 (F=24.15; df 1,84; p < .01). The interaction B x SP also reached significance (F=2.59; df 8,224; p < .05) and this was analysed further for simple main effects. From Table 51 it can be seen that the effect of blocks is significant at positions 4-6 (F=7.51; df 4,336; p < .01) and at positions 7-9 (F=4.92; df 4,336; p < .01). Performance on the later serial positions tended to improve as time on task increased.

<u>NN v. NQ comparison</u>

Only the main effect of serial position reached significance (F=55.99; df 2,56; p < .01) and comparisons between means revealed that significantly more digits were recalled from positions 1-3 than from positions 4-6 (q=9.88; df 3,56; p < .01) and from positions 7-9 (q=14.63; df 3,56; p < .01). Similarly more digits were recalled from positions 4-6 than from positions 7-9 (q=4.74; df 3,56; p < .01). The main effect of blocks approached significance (F=2.49; df 4,112; p < .10) with performance tending to improve with time on task up to the fourth block of 10 trials. However performance tended to deteriorate on the final block of 10 trials.

<u>NN v. QQ comparison</u>

The main effects of noise (F=4.83; df 1,38; p < .05) and serial position reached significance. Performance in NN was better than that in QQ. Comparisons between means for the main effect of serial position revealed that significantly more digits were recalled from positions 1-3 than from positions 4-6 (q=11.12; df 3,76; p < .01) or positions 7-9 (q=17.95; df 3,76; p < .01). More digits were also recalled from positions 4-6 than from positions 7-9 ($q=6.84$; df 3,76; $p < .01$). The interaction N x SP approached significance ($F=2.60$; df 2,76; $p < .10$) and from Figure 29 it can be seen that the beneficial effects of NN compared with QQ tend to be confined to later serial positions.

Spearman rank correlation coefficients were also computed between the number of digits recalled and the number written down in the order 1-9 for each N condition and these are given in Table 52.

(iii) Comparison between serial and simultaneous presentation

To investigate the possibility of differential effects of noise on serial and simultaneous presentation, the results of Experiment 4 and Experiment 6 were compared statistically. A 2 x 4 x 3 (serial/simultaneous; serial positions 1-3, 4-6, 7-9; noise condition NN, NQ, QN, QQ) unweighted means analysis of variance with repeated measures on the second factor was carried out on the recall data for Trial 1 only from the two experiments, and the summary table of this analysis is given in Table 53a. The table reveals a significant main effect of type of presentation ($F=23.81$; df 1,112; $p < .01$) with significantly more digits recalled after simultaneous presentation than after serial presentation, and serial position ($F=36.55$; df 2,224; $p < .01$). Comparisons between means for the main effect of serial position using Tukeys method revealed that significantly more digits were recalled from positions 1-3 than from positions 4-6 ($q=7.75$; df 3,224; $p < .01$) or from positions 7-9 ($q=11.5$; df 3,224; $p < .01$). Similarly, more digits were recalled from positions 4-6 than from positions 7-9 ($q=3.75$; df 3,224; $p < .01$). The first order interaction SP x N also reached

Table 52

Spearman Rank Correlation Coefficients Between Number Order 1-9 and Total Number Digits Correct

	NN	NQ	QN	QQ
r_s =	0.46	0.36	0.25	0.05
	(n=20)	(n=10)	(n=10)	(n=20)

Figure 29 Figure showing probability of recall as a function of serial position for Trials 6-55 - Experiment 6.

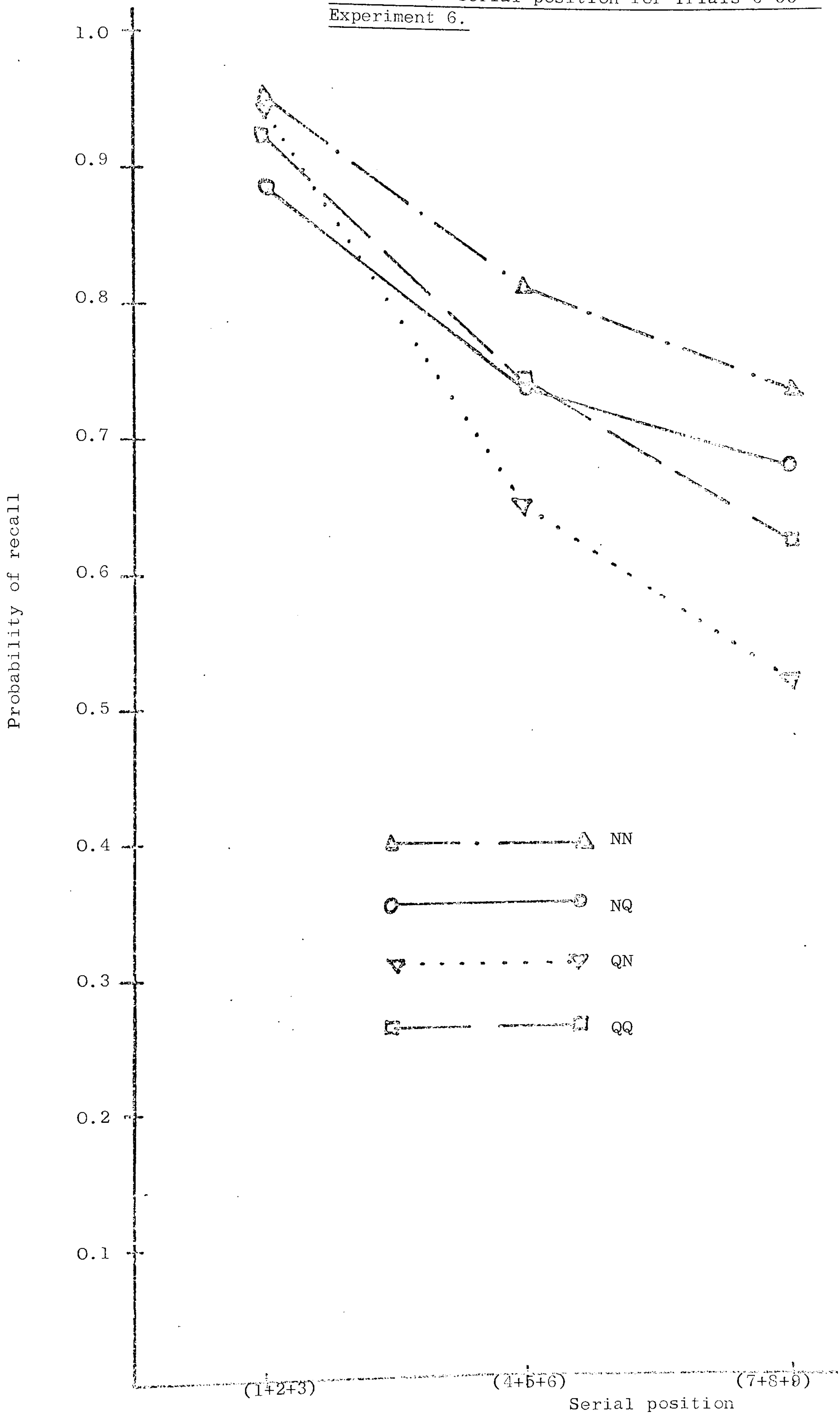


Table 53a

Anova Type of Presentation x Serial position x Noise (Trial 1 only)

Source	SS	df	MS	F
Type of presentation (P)	54.42	1	54.52	23.81**
Noise (N)	5.06	3	1.69	<1
P x N	9.73	3	3.24	1.41
Subj. w gps.	256.84	112	2.29	
Serial position (SP)	46.79	2	23.39	36.55**
P x SP	1.60	2	0.80	1.25
SP x N	14.26	6	2.38	3.72**
P x SP x N	2.00	6	0.33	<1
SP x Subj. w gps.	143.96	224	0.64	

Table 53b

Summary table for simple main effects (N x SP)

Source	SS	df	MS	F
N at SP_1	4.40	3	1.47	1.23
N at SP_2	2.27	3	0.76	<1
N at SP_3	12.66	3	4.22	3.55**
Error		336	1.19	
SP at N_1	10.13	2	5.06	7.91**
SP at N_2	3.33	2	1.66	2.59+
SP at N_3	31.99	2	15.99	24.98**
SP at N_4	15.60	2	7.80	12.19**
Error		224	0.64	

significance ($F=3.72$; df 6,224; $p < .01$) and was analysed further for simple main effects, for which the summary table is given in Table 53b.

A 2x5x4x3 (serial/simultaneous, blocks of ten trials, noise conditions NN, NQ, QN, QQ; serial positions 1-3, 4-6, 7-9) unweighted means analysis of variance was also carried out on the recall data for trials 6-55 from Experiments 4 and 6, and the summary table for this analysis is given in Table 54a. From the table it can be seen that all main effects, type of presentation ($F=30.75$; df 1,112; $p < .01$), blocks of ten trials ($F=10.92$; df 4,448; $p < .01$) and serial position ($F=90.03$; df 2,224; $p < .01$) reached significance. As with the data from Trial 1 only, significantly more digits were recalled after simultaneous presentation that after serial presentation. Comparisons between means for the main effect of blocks using Tukey's method revealed that significantly fewer digits were recalled in the first block of ten trials than in the third block ($q=7.23$; df 5,448; $p < .01$), the fourth block ($q=7.86$; df 5,448; $p < .01$) or the fifth block ($q=7.09$; df 5,448; $p < .01$). Similarly, fewer digits were recalled from the second block than from the fourth block ($q=4.36$; df 5,448; $p < .05$). Comparisons between means for the main effect of serial position, using Tukey's method revealed that significantly more digits were recalled from positions 1-3 than from positions 4-6 ($q=14.18$; df 3,224; $p < .01$) or from positions 7-9 ($q=18.23$; df 3,224; $p < .01$). Similarly, more digits were recalled from positions 4-6 than from positions 7-9 ($q=4.06$; df 3,224; $p < .05$). The first-order interactions P x N ($F=4.36$; df 3,112; $p < .01$), P x SP ($F=12.55$; df 2,224; $p < .01$) and B x SP ($F=2.31$; df 8,896; $p < .05$) all reached significance as did the second-order interaction P x N x SP ($F=2.58$;

Table 54a

Anova Type of Presentation x Blocks of 10 trials x Noise x Serial Position - Trials 6-55

Source	SS	df	MS	F
Type of presentation (P)	6,912.14	1	6,912.14	30.75**
Noise (N)	936.83	3	312.28	1.39
P x N	2,941.13	3	980.38	4.36**
Subj. w gps.	25,178.45	112	224.81	
Blocks (B)	693.43	4	173.36	10.92**
P x B	55.19	4	13.80	<1
B x N	122.90	12	10.24	<1
P x B x N	339.78	12	28.31	1.78+
B x Subj. w gps.	7,108.08	448	15.87	
Serial position (SP)	11,291.71	2	5,645.85	90.03**
P x SP	1,574.14	2	787.07	12.55**
N x SP	595.58	6	99.26	1.58
P x N x SP	971.49	6	161.91	2.58*
SP x Subj. w gps.	14,047.94	224	62.71	
B x SP	148.23	8	18.53	2.31*
P x B x SP	47.85	8	5.98	<1
B x N x SP	140.36	24	5.85	<1
P x B x N x SP	137.83	24	5.74	<1
B x SP x Subj. w gps.	7,175.89	896	8.01	

df 6,224; $p < .05$). The first-order interactions were analysed further for simple main effects and the tables for these analyses are given in Table 54b, c and d.

8.3 Discussion

The comparison between the NQ and QQ conditions in the present experiment with the simultaneous presentation of items yielded very similar results to the corresponding comparison in Experiment 4 with sequential presentation, with noise during presentation tending to result in better recency but slightly worse primacy (see Figure 29). These results, therefore, are not inconsistent with the view that noise facilitates phonemic coding. Similarly, if, when subjects recall in quiet, they adopt the backward scanning mode of retrieval, then little overall difference between the NQ and QQ conditions would be expected and this was indeed found to be the case (77% recalled in NQ compared with 76.4% recalled in QQ).

Thus the results of the NQ and QQ conditions do not appear to suggest that there may be differences in the type of encoding employed in organising simultaneously presented items, rather than serially presented ones, although it is possible that there may be such differences, but that they are affected by N in the same way as those employed during serial presentation.

However, the comparison between the QN and NN conditions in the present experiment and those in Experiment 4 reveals a noticeable

Table 54b

Summary table for simple main effects (P x N)

Source	SS	df	MS	F
P at N_1	3,720.00	1	3,720.00	16.55**
P at N_2	2,929.67	1	2,929.67	13.03**
P at N_3	27.06	1	27.06	<1
P at N_4	3,176.40	1	3,176.40	14.13**
Error		112	224.81	
N at A_1	1,525.75	3	508.58	2.26+
N at A_2	2,352.21	3	784.07	3.49*
Error		112	224.81	

Table 54c

Summary table for simple main effects (P x SP)

Source	SS	df	MS	F
P at SP_1	5,345.46	1	5,345.46	45.79**
P at SP_2	2,826.76	1	2,826.76	24.21**
P at SP_3	314.05	1	314.05	2.69
Error		336	116.74	
SP at P_1	10,192.25	2	5,096.12	81.26**
SP at P_2	2,673.60	2	1,336.80	21.32**
Error		224	62.71	

Table 54d

Summary table for simple main effects (B x SP)

Source	SS	df	MS	F
B at SP_1	58.25	4	14.56	1.37
B at SP_2	468.82	4	117.20	11.02**
B at SP_3	314.59	4	78.65	7.40**
Error		1,344	10.63	
SP at B_1	2,868.08	2	1,434.04	75.67**
SP at B_2	2,600.42	2	1,300.21	68.61**
SP at B_3	1,902.59	2	951.29	50.20**
SP at B_4	1,993.50	2	996.75	52.59**
SP at B_5	2,075.35	2	1,037.67	54.76**
Error		1,120	18.95	

difference between the two sets of results. Whereas in Experiment 4, recall in QN tended to be better than that in NN (as it did in Experiments 4A and 5 which also used serial presentation) in the present experiment, the NN condition resulted in significantly better recall than that in the QN condition. If subjects adopt the reconstructive mode of retrieval when they recall in noise, then this mode of retrieval appears to be more sensitive to the effects of noise at input than the scanning operation. It was suggested by Craik and Jacoby (1976) that when subjects adopt the backward scanning mode of retrieval, less deep levels of encoding are as efficient as semantic encoding whereas when they adopt the reconstructive mode, deeper levels of processing would be expected to result in better recall performance. Since, in the present experiment, which employed short lists of digits as stimuli, semantic coding was unlikely to occur, it would appear that other differences in encoding strategy or organisation can affect this mode of retrieval. Thus noise, compared with quiet, during the simultaneous presentation of items seems to result in improved recall performance only when recall is undertaken in noise. The reasons for this are unclear. A possibility is that noise encourages subjects to group their material differently. In serial presentation, the items are presented at a uniform rate, whereas with simultaneous presentation, subjects can scan the 9-digit list at will. However, it is assumed that all the subjects will receive the digits in the same temporal order since Bryden (1967) reports that when English speaking subjects are given a horizontal row of stimulus material, they tend to report it from left to right whether the stimulus elements are letters, geometric forms, or binary patterns of open and filled circles. Thus with simultaneous presentation, although the temporal order in which the subject receives the stimuli is probably constant, there is more opportunity for subjects to organise or group their material differently. It is suggested that in noise subjects may temporally group their material more regularly. This could account for the enhanced recency effect in the NQ condition compared with the QQ condition, since regular temporal grouping has been shown to exert its beneficial effects in the recency portion of the serial position curve (Herriott, 1974). The comparison between the NN and QN conditions thus appears to suggest that if noise at input encourages regular grouping to a greater extent than in quiet, then this type of organisation is beneficial to the reconstructive mode of retrieval.

Since Experiment 4 and the present experiment were similar and employed the same type of material to be recalled (9-digit sequences) and the same number of trials and noise conditions, the two experiments were compared statistically (see Section 8.2for details of the analysis). The simultaneous presentation of items resulted in significantly better overall recall performance than serial presentation, a result in agreement with those of Crowder (1966) and Mackworth (1962b, c). From Table 54 it can be seen that a significant interaction was obtained between type of presentation and serial position, with simultaneous presentation resulting in better performance on serial positions 1-3 and 4-6 while the difference between presentation types was not significant for serial positions 7-9. Thus the beneficial effect of simultaneous presentation is mainly due to improved performance on early serial positions rather than on later positions, and this would be expected since the subject has more opportunity to organise and rehearse his material.

Considering the data on the number of responses recorded in the order 1-9, similar results were obtained to those in Experiment 4 in that when subjects recalled in noise, more responses tended to be in the order 1-9 than when they recalled in quiet. However, noise during presentation tended to result in fewer rather than more serial responses. Overall, however, far more responses were recorded in the order 1-9 after simultaneous presentation than after serial presentation and this could be a contributing factor in the improvement of recall in early serial positions for simultaneous presentation.

8.4 Conclusion

On the whole, the results of Experiment 6 suggest that the effects of noise during presentation upon recall performance are partly determined by the type of presentation of the material to be remembered and by whether or not the noise is present during recall and a possible explanation of such effects is considered.

CHAPTER 9

NOISE AND INDIVIDUAL DIFFERENCES

Invididual differences may exert an influence on the effects of noise upon efficiency and it is to this area that attention is now directed. Comparatively few studies have examined individual differences in the effects of noise and the great majority of these have been concerned with various dimensions of personality, e.g. introversion, anxiety etc. The inventories most commonly used for these studies have been the Maudsley Personality Inventory (MPI, Eysenck, 1959) or more recently the Eysenck Personality Inventory (EPI, Eysenck and Eysenck, 1964) to obtain a person's position on the extraversion-introversion dimension. Other studies have employed the Minnesota Multiphasic Personality Inventory (MMPI - Dahlstrom and Welsh, 1962) to obtain measures on various dimensions of personality e.g. psychoasthenia, hysteria etc. and the Taylor Manifest Anxiety Scale (Taylor, 1953) to obtain a measure on the level of anxiety. However, one or two studies have examined the possible differences in the effects of noise upon males and females and differing age groups, and these will be considered separately after a brief review of the influence of personality factors upon the effects of noise upon efficiency.

9.1 Personality Factors and Noise Effects

There have been basically two types of study investigating the possible relation between aspects of personality and the effects of noise upon performance. In the first type of study, the effects of noise on performance of different personality groups have been examined. The tasks employed have included tests of mental ability, vigilance and tracking tasks. The second type of study has mainly been concerned with individual differences in tolerance to noise and the possible relation between a person's level of tolerance and his personality.

Two early studies concerned with individual differences (Barrett and Blau) are cited by Corso (1952). In Barrett's study, subjects after having completed the MMPI, worked at the California Capacity Questionnaire in 105dB N or Q, with all subjects receiving both conditions on separate days. No overall differences in performance were found between N and Q, but individuals who performed better under N than Q appeared 'normal' on the MMPI scales, while subjects who performed worse under N than Q revealed a significant paranoid trend on the MMPI scales. Blau utilised a test of maladjustment as well as the MMPI in his investigation of the possible relation between performance at the Otis Self Administering Test under noise at 103dB or 50dB and scores on the personality inventory. Blau found no difference between the N and Q conditions in the number of items correct, but significantly more incorrect items occurred in N than in Q. In this study, however, neither the MMPI, nor the test of maladjustment used (the McFarland-Seitz P-S Blank) was successful in differentiating those individuals whose performance deteriorated under noise.

However, other studies have been more successful in isolating certain personality factors which could , in part, account for the large individual differences in performance under noise. Angelino and Mech (1955) selected subjects, of which half were 'high' and half 'low' in 'total adjustment' as measured by the California Test of Personality. Performance at an addition task under 85dB noise was significantly better for the 'low' adjustment group than for the 'high' adjustment group. Auble and Britton (1958) selected subjects on the basis of their scores on the Taylor Manifest Anxiety Scale. Subjects performed a series of number checking and name checking exercises in 80dB noise or quiet. A significant interaction between the noise condition and the level of anxiety was obtained with the most anxious subjects performing significantly better under N than they did under Q, while the least anxious subjects performed better (though not significantly so) under Q. However, a more recent study (Basow, 1974) concerned with the effects of white noise on attention as a function of anxiety yielded results which appear inconsistent with those above. Subjects, who were sub-divided into groups of low, medium and high anxiety, according to scores on the Epstein-Fenz Manifest Anxiety Scale, worked at attention tasks in noise (100dB) or quiet. Noise interacted with anxiety on two of the tasks such that subjects low in anxiety improved with noise, while moderately anxious subjects deteriorated with noise, and highly anxious subjects remained the same.

Another personality factor which has received considerable attention in the area of vigilance research is the introversion-extroversion dimension of Eysenck (Eysenck, 1967). The vigilance performance of extraverts and 'normals' tends to decline with time on task, while that of introverts remains relatively stable (Bakan, Belton and Toth, 1963). Davies and Hockey (1966) found that the decrement observed in extraverts in Q (70dB), at both low and high signal frequencies was not apparent in 95dB N. Noise, compared with Q, significantly increased the number of correct detections made by extraverts under the condition of low signal frequency, but a similar increase under a high signal frequency condition was not significant. Noise had no significant effect on the number of correct detections made by introverts at either signal frequency. Significantly more commission errors were made by extraverts, and significantly less by introverts in N compared with Q. Results were interpreted in terms of the inverted U theory of arousal.

Hockey (1972) examined individual differences in the degree of selectivity shown in his dual task situation described previously (Chapter 1, section 1.1.4.2). He found that while introverts tend to emphasize the high priority demands of a complex task under normal environmental conditions, extraverts tended to show a greater change towards the appropriate distribution of attention under N. A similar pattern emerged under conditions of sleep deprivation, with extraverts displaying the greater change in attention distribution. Hockey suggested that the performance of introverts is relatively stable, irrespective of the prevailing environmental conditions, while that of extraverts seems much more labile and may be considerably affected in a positive or negative direction by stress. However, not all attempts to relate the extravert-introvert dimension of personality to efficiency have proved successful. Hummel, Cohen and Turner (1965) found no significant relationship between vigilance performance in N and various personality measures, including those of introversion and anxiety.

It has been suggested that the level of anxiety or neuroticism interacts with the extravert-introvert dimension to determine the effects of noise (Stephens, 1972; Woodhead, 1969) and this factor has not always been controlled for in studies of individual differences in the effects of N (Broadbent, 1971). Personality differences still appear, however, even when such controls are applied. Nevertheless, why these individual differences in response appear is not yet fully understood.

Eysenck (1967) has proposed that extraverts are characterised by 'stimulus hunger' with the consequence that they constantly seek changes in their current environment. Support for this general hypothesis comes from the results of a number of studies (Gale, 1969; Davies, Hockey and Taylor, 1969). Davies et al. found that when given the opportunity to select brief segments of varied noise during performance of a vigilance task, extraverts selected the varied noise significantly more frequently than did the introverts. In a second experiment, however, when given the opportunity to obtain short periods of silence, introverts selected such periods significantly more often than did extraverts. The differences in efficiency were not related to these differences in preferences. Hockey (1972) reports a study in which extraverts and introverts were asked to adjust 100dB continuous white noise to a 'comfortable working level' every 5 minutes during performance of a 30 minute task. Although the preferred level for both groups increased significantly with time at work, extraverts consistently set the level higher than the introverts.

A similar finding was obtained by Elliott (1971) using 5 and 10 year olds as subjects. The children's level of extraversion was assessed by teachers' ratings and, in the case of the older group, by the Junior EPI. When subjects who were presented with a continually increasing level of N through earphones could not bear the noise to get any louder, they could prevent this happening by pressing a button which caused the N level to start decreasing. When the N level was soft enough, the subject could release the button at which time the noise would again increase and so on. Elliott found that boys tolerated a level almost 10dB higher than did girls, that there was no difference between the age groups and that there was a marked difference between the tolerance levels of extraverts and introverts, the former group having a noise tolerance level over 30dB higher than the latter group.

However, not all attempts to relate personality measures to either noise tolerance or, in some cases to efficiency have been successful. As previously mentioned, Hummel et al. (1965) found no relationship between various personality measures, including introversion and efficient performance on a vigilance task under noise. However, subjects were also required to rate various Ns as to their respective objectionality or annoyance and it was found that N tolerant subjects performed significantly better than N intolerant subjects under high level noise and variable N. Nevertheless, no significant relationship was found between the various personality measures utilised and the level of N tolerance. In conclusion, the evidence suggests that both the noise tolerance, and the personality characteristics, of the individual are important determinants of the effects of noise upon that person's level of performance.

9.2 The Effects of Age and Sex in Noise Research

The study of the possible differential effects of noise upon the performance of men and women or upon that of different age groups has received scant attention, and thus little can be reported here. Using a dual-source adding task, Samuel (1964) found that in noise women performed significantly better than men. Two other studies (Miller, 1963; Archer and Margolin, 1970) suggest possible sex differences in performance under N, but their results would appear contradictory, although the tasks they employed were very different. The results of Miller (1963) suggest that women's visual perception is facilitated by auditory stimuli (4000Hz or 500Hz tone at 85dB) to a greater extent than men's. Archer and Margolin, using a memory task, found that WN facilitation occurred for women, but that it also occurred, and to a greater extent, for men. Thus it would appear that sex differences in performance under N do occur, and obviously more research is needed in this area.

The performance of different age groups under noise has received even less attention. It is frequently assumed that older individuals will be more susceptible to the effects of environmental stress than will younger people. It has been argued that increasing exogenous stimulation, including high N levels, has a detrimental effect upon the performance of older individuals, principally because a state of physiological over-arousal is produced which impairs efficiency. Davies and Davies (1975) investigated the effects of 95dB A noise upon the performance of older subjects (men aged between 65-72 years) and younger subjects (men aged between 18-31 years) at an inspection and a proof reading task. Subjects were tested either in the morning or in the afternoon. The two age groups were matched on various measures including verbal intelligence and sociability, and audiometric tests were carried out. On both tasks, the performance of the older men was significantly worse than that of the younger ones, but it was not impaired to a greater extent by noise and if anything, their performance related to that of the younger individuals, tended to improve slightly in noise in both the morning and afternoon sessions. Also, the performance of the older subjects in Q was significantly better in the afternoon compared with the morning, whereas the performance of the younger subjects was not affected significantly by time of testing. Thus the results of this study would seem to indicate that 'high arousal' conditions, such as N and afternoon testing do not impair the performance of older subjects, whatever the physiological effects may be, and if anything, their performance shows a relative improvement under these conditions. In adapting their performance to N conditions, older subjects seem to be as efficient as younger ones.

9.3 Sex and Personality Factors in the Present Study

It would thus seem that individual differences can influence noise effects upon efficiency, although the nature of such an influence remains far from clear. It was therefore considered desirable to examine the foregoing experiments for possible differential effects of noise upon the efficiency of males and females. Furthermore, subjects in Experiment 5 completed the EPI and thus the possible effects of level of extraversion on efficiency in noise was also investigated. Analyses of variance including a sex factor were computed for each experiment and the summary tables for these are given in the Appendix (those for Experiment 1 are given in Appendix 1, those for Experiment 2 in Appendix 2 etc.). The main effect of sex was siginficant in only one analysis (Experiment 1 - free recall) with females recalling significantly more words than males.

While there has been extensive research on sex differences in a number of areas - creativity, aggressiveness, attitudes, intelligence, there has been scant interest in the question of sex differences in memory. Epstein (1974) suggests that a review of the literature over the last 25 years reveals only a handful of studies concerned with sex differences, and these mainly show trends in the same direction as that obtained in Experiment 1. Duggan (1950) tested school children between the ages of 14 years and 16 years for word and number memory. She found that females correctly recalled more words than males on the free recall test, although males recalled more numbers than females. A similar finding showing superior word recall for females was reported by King (1959) and Cofer, Diamond, Olsen, Stein and Walker (1967) found that females learned paired-associates under the recall method significantly faster than males. However, the above studies did not attribute the observed female recall superiority to a 'real' sex difference, but to a random sampling error or other artifacts and these would appear to be the most parsimonious explanations for the obtained sex effect in Experiment 1, particularly since this effect was not noted in any of the other experiments.

From the summary tables in the Appendix it can also be seen that none of the first-order interactions involving the sex factor reached significance at the 5% level, although one or two approached significance ($p < .10$), but not one was an interaction between noise and sex.

The first-order interactions which approached significance were SP x Sex in Experiment 4 in which the recall performance of males tended to be better than that of females on early serial positions, while the reverse tended to be the case on later positions. In Experiment 5, the sex x presentation rate interaction approached significance and revealed a tendency for the recall of males to be superior to that of females after slower presentation rates, whereas for faster rates the reverse was the case. In Experiment 6, the sex x blocks of 10 trials interaction approached significance with the recall of males tending to be superior to that of females during the first three blocks of trials, but after this, little difference in recall performance between males and females was apparent.

Finally, two higher-order interactions involving the sex factor reached significance (Noise x Sex x Retention Interval x Serial Position in Experiment 2 and Noise x Sex x Serial Position in Experiment 4A, ordered recall) for the data for Trial 1 only in both cases, but neither interactions were significant for the data from the main block of trials, hence raising problems of interpretation. Since most of the above interactions only approached significance it would seem reasonable to suggest that sex effects in noise and memory research are minimal and those that do appear could well be due to artifacts.

The investigation of possible effects of level of extraversion on efficiency in noise in Experiment 5 also yielded little evidence for such effects. Spearman Rank Correlation Coefficients between extraversion score and the total number of digits correct were computed for each experimental condition and these are shown in Table 73, from which it can be seen that in only the QN condition for the 1/sec. presentation rate did the coefficient reach significance (r_s = 0.64;

n = 10; p .05), there being a positive relationship between the level of extraversion and the total number of digits recalled, in that condition, Since previous research (e.g. Wilding, 1977, Experiment 2) has suggested that the performance of extraverts on short-term memory tasks is better than that of introverts a positive correlation would be expected in the control condition (QQ) in the present study, but in fact the coefficients in this condition were all very small and failed to reach significance. Similarly in the other experimental conditions coefficients were generally low and insignificant, suggesting no obvious relationship between level of extraversion and noise effects on performance at memory tasks.

Similarly Spearman Rank Correlation coefficients between the level of extraversion and the number of responses recorded in the order 1-9 were also computed for each noise condition and these are given in Table 74. From the table it can be seen that when subjects recalled in quiet, there tended to be a positive relationship between the level of extraversion and the number recorded in the order 1-9, although this only reached significance in the NQ condition, (NQ, n=10 1/sec. $r_s = 0.88$. $p < .01$, 2/sec $r_s = 0.77$, $p < .01$, 3/sec r_s 2 0.66, $p < .05$), but when subjects recalled in noise there tended to be a negative relationship between level of extraversion and the number recorded in the order 1-9, although only one coefficient reached significance (QN, 1/sec, n = 10; $r_s = 0.58$; $p < .05$). Thus it would seem that level of extraversion appears to be related to the type of strategy which the subject adopts for recall, but this relationship is dependent upon the noise level at recall. Since only one experiment in the present study examined possible personality factors in the effects of noise upon memory tasks it is difficult to draw conclusions about the results obtained. The lack of any obvious relationship between level of extraversion and recall performance is in agreement with the results of Daee and Wilding (1977) but an examination of subjects' preferred response strategies in conditions of noise or quiet would seem to warrant further investigation.

CHAPTER 10

DISCUSSION AND CONCLUSIONS

Since the present experiments were started other experiments examining the effects of noise on memory tasks have been published (e.g. Eysenck, 1975; Daee and Wilding, 1977) which have attempted to elucidate further the various hypotheses concerning noise effects on memory.

On the whole the present results suggest that noise during the presentation of a set of items to be remembered does not result in deleterious effects but rather in a tendency towards facilitatory effects upon immediate short-term memory. Although this effect was small, it was, nevertheless, fairly consistent over all experiments and was more marked for ordered recall than free recall, in agreement with the findings of Hockey and Hamilton (1970).

These results are also not inconsistent with Dornic's suggestion that noise acts like other methods of increasing task difficulty and induces regression to a more primitive 'parrotting back' form of learning that is repeating back the items in order. In a number of studies, Dornic found that several methods of increasing task difficulty had little effect on the retention of lists of items in the correct order, but reduced the probability of recall when order was not retained. It was as if the 'more difficult' conditions had not affected the more mechanical way of recall, that is 'parrotting back' the items in their original order, and the items could easily be recalled as long as they were 'pasted together' according to the input order. In other words, the retention of item information in the 'more difficult' conditions (e.g. in noise) seemed largely to depend on the retention of order information; having forgotten the order, the subjects lost at the same time a great deal of item information. Dornic pointed out that although at first sight it might seem that with unrelated items, the recall of what was presented and in which order it was presented should always be more difficult than the recall of item information alone, this is not always true in situations favouring recall of an echoic type. Dornic suggests that in certain cases, storing information in an echoic way, in the form of unseparated chain-traces, appears to be the easiest way of preserving it for a short period of time. Dornic postulated two different levels of short-term storage mechanism. A 'lower' storage mechanism representing an 'easier' or more economical way of coding, primarily relying on undifferentiated chain-traces i.e. it carries more order information. This system may store the arriving information primarily according to the physical features rather than according to the meaning of the individual items. Activation of the stimulus names in long-term memory is not necessarily involved at this stage. A 'higher' storage mechanism might then represent a 'more difficult' way of coding, involving identification of the stimuli according to their names or according to semantic features stored in long-term memory, rather than according to their physical features. The traces of the individual items within messages thus become more 'independent' or 'loose' and less connected together in the order of presentation. Analysis or identification of items involved in this 'higher' storage operation inevitably tends to weaken the links between unrelated items and thus to disrupt order formation. Dornic suggests that the 'lower' more rudimentary storing mechanism relying heavily on order information operates in situations roughly described as 'more difficult'.

He further suggests that in some cases, difficulty is self-evident, although in some cases it is unclear if a situation is to be described as easier or more difficult. Hockey and Hamilton (1970) compared retention of order and item information in quiet and in noise. They found that the percentage of words recalled irrespective of order was somewhat lower (though not significantly) in noise (80dB) than in quiet. However, there was a clear tendency for recall in noise to be better (p=0.055) when correct order was taken into account. The author's comment was that subjects in the noise condition attend more to order cues present in the list. Hamilton, Hockey and Quinn (1972) suggested that better performance in noise on a paired-associate learning task when the items were kept in order was due to an 'increase in processing power'. Dornic points out, however, that one may also say that under the influence of noise, the subjects were obliged to rely more on the 'lower' more rudimentary way of coding. Thus, noise might be seen as a 'more difficult' condition. The present findings of a tendency for beneficial effects of noise on ordered recall and little overall effect on free recall could thus be explained in terms of Dornic's theory, particularly if this low-level type of coding was beneficial for the immediate recall of short strings of unrelated words or digits. However, the criterion for retention of order information in the majority of Dornic's studies was the subject's ability to recall strings of unrelated items in the order of input rather than his ability to locate or recall the positions of the individual items in a string independently. Using different measures of ways of recall, one is likely to measure different things under the same name. While retention of order information as specified by Dornic might mean reduction of the overall information, retention of order information as measured for example by ordered recall or by 'filling-in-boxes' on a sheet, by cueing subjects to recall which items had occupied different spaces on a screen or in particular by backward recall, suggests increasing the information retained, since it is necessary to remember the positions of the individual items. In the latter case, the retention of order information would probably be due to more learning than retention of item information only, because the recall often requires the 'breaking up' of a phonologically coded 'chain-trace' and treating the individual items in a string as independent units. Thus recall of order may reflect either recall of position in the list or recall of sequential relations of items or both and recall of position in the list may depend on recall of relative distance from the end of the list or recall of ordinal position. Recent work by Daee and Wilding (1977) on the effects of noise on memory has attempted to disentangle, at least partially, the recall of position and the recall of sequences by examining the probability of recall in sequence when position is not recalled, and recall of position when the preceding item is not available as a cue for sequence. In two of their experiments, Daee and Wilding tested retention of list position directly and of sequence indirectly by requiring subjects to place items in their original position in the list. In one experiment subjects did not know beforehand the type of recall that would be required, so learning was incidental, in the other, they were told beforehand the type of recall that would be required, so learning of position was intentional. However, it does not follow from the recall requirement to place items in position that subjects actually carry out either the recall or learning by doing just that. They may use position cues alone, or sequence cues alone, or both position and sequence cues. Thus in their scoring of results, recall of both position and sequence information was examined. Daee and Wilding found that when learning was incidental, memory for position improved as noise intensity increased, while memory for sequence was better at 75dB than at 85dB or than in quiet; thus suggesting that noise intensity affects memory for sequence and position, though not in exactly the same way. However, when learning was intentional, no significant effect of noise intensity on either measure was observed. This finding of improved recall for position at higher noise levels when the nature of the recall was unknown and the finding that intentional learning was not affected by position could be interpreted as suggesting that the former result is due to a strategy such as the use of a lower order memory process adopted during learning which can be induced by instructions or high intensity noise. Considering the two relevant conditions (NQ v. QQ) in the present study which were similar to those of Daee and Wilding, the results are consistent with their data since the subjects knew beforehand that they would be required to place the items in their correct position and could be explained along similar lines. In experiments 2-5 inclusive, the NQ condition tended to result in slightly better performance than that in QQ, but these differences failed to reach significance. Dornic would predict better recall of position when learning is incidental as noise level increases, if the learning of position is involved in the order effects he observed. However, when position learning is intentional, Dornic would presumably predict that noise intensity should have little or no effect, although this is not altogether clear since he does not state whether or not the higher memory process can be voluntarily suppressed in favour of the lower process which handles order, when following an instruction to learn position. If this does occur, then noise would be expected to have little effect on the intentional learning of position. The effects of noise on sequence learning in Daee and Wilding's study were less clear and indeed the observed result of a non-monotomic relationship between noise intensity and recall of sequence would not be predicted by Dornic. However, since the present study did not examine the recall of sequence as such, but rather the recall of position it cannot provide further evidence on the relation between noise intensity and recall of sequence.

An alternative explanation to that suggesting that high intensity noise actually affects cognitive operations on the input e.g. Dornic and Schwartz, is that of Hockey and Hamilton (1970) who point out that noise increases arousal which in turn affects the distribution of attention and they suggest that this produces an additional and preferred method of organising recall. Although this interpretation of noise effects is mainly concerned with tasks with two inputs, nevertheless it could be relevant to the present study if position is treated as an irrelevant additional cue. Hockey and Hamilton would then predict worse recall of position as noise intensity increased when subjects did not know beforehand that position recall was required. However, they would also predict that noise intensity should have little or no effect when position is to be learned intentionally since attention can be focussed on this by instructions. Thus the results of Daee and Wilding on the intentional recall of position, and indeed those of the present study could also be explained by Hockey and Hamilton's views. In the present study only one experiment (Experiment 1) involved the examination of noise effects upon the distribution of attention over two aspects of a task and this yielded only weak evidence for selectivity in noise. Nevertheless this results in conjunction with those of other workers (e.g. Davies and Jones, 1975) would seem to suggest that noise affects the distribution of attention over the various components of a task, resulting in increased attention being directed to the more important aspects of it, while the reverse holds for less important aspects.

Nevertheless, over and above any effect of noise on the distribution of attention, there would seem to be other effects of noise. In the present study the tendency for an improvement in recall in noise (during presentation) was mainly to an enhancement on the recency portion of the serial position curve. Thus improvement in recency could be explained by Dornic, since he suggests that the lower storage mechanism represents an easy economical way of coding, probably phonological coding. If the type of coding determines the durability of the memory trace, with phonemic coding of verbal material being simple and rapid and leaving an adequate primary memory trace accompanied by a relatively minor secondary component, whereas the semantic coding of unrelated material is relatively slow, but leaves a much more durable secondary memory trace (Baddeley and Ecob, 1970) then the beneficial effects of noise on the recency portion of the curve would be expected, since recency is usually considered to reflect output from primary memory.

It is a well-established finding that the recency effect disappears with delayed recall and if noise is exerting its effects upon the recency portion of the curve, then the beneficial effects of noise would not be expected with delayed recall. Indeed, a deleterious effect of noise on delayed recall might be expected, since phonemic coding is not as efficient as deeper levels of processing when recall is not immediate. It has been pointed out by Jacoby and Bartz (1972) that the type of processing adopted by a subject is under his own control and if delayed recall after a rehearsal-preventing activity is anticipated then deeper levels of processing are required and adopted. The results of Experiment 2 therefore could be taken as suggesting that noise prevents deeper levels of processing. Work by Schwartz (Schwartz, 1975a, b) suggesting that high arousal leads to increased selection of information about the physical characteristics of presented information and to decreased processing of semantic information is consistent with the present findings.

The results of Experiment 2, however, are not inconsistent with Poulton's proposal that noise masks rehearsal loops in verbal short-term memory. Since rehearsal is usually assumed to be the process whereby items in primary memory can be transferred to secondary memory then if noise masks rehearsal loops, then items are less likely to be transferred to the more permanent secondary memory and while items in primary memory can be recalled immediately with reasonable efficiency, they are extremely vulnerable to decay (Waugh and Norman, 1965). The present study cannot rule out this interpretation of the effects of noise during the presentation of items. However, a possible test of this hypothesis would be to examine the effects of another stress which is assumed to raise arousal upon a similar task to that in Experiment 2. If the effects of noise are merely due to the masking of rehearsal loops, then high arousal should not adversely affect delayed recall. However, if similar results to those in noise are obtained then the proposal that shallower levels of processing tend to operate under conditions of high arousal would appear more tenable.

The majority of other studies on the effects of noise on immediate memory would appear to be consistent with the explanation in terms of shallower levels of processing provided certain conditions prevail, for example, the recall is immediate, the number of items to be recalled is fairly small and ordered recall is required. Under these conditions one would expect phonemic coding to be optimal for the particular task and thus the effects of continuous noise would be either to enhance recall or at least to have no detrimental effect. Experiments employing these conditions have yielded results in the expected direction (e.g. Hockey and Hamilton, 1970; Davies and Jones, 1975). Where adverse effects of noise have been obtained on short-term learning and memory, the 'immediate' recall condition has often been two minutes after the presentation of the final item in the list (e.g. McLean, 1969) in which case such an effect would be expected since phonemically encoded items are unlikely to survive such a delay. When free recall of short lists is required, the overall effects of noise would appear to be slight, since an improvement in the recency portion of the serial position curve would be expected in conjunction with a small detrimental effect on the primacy area. Very few studies have examined the effects of noise on free recall, and of those which have, serial position data have seldom been given. However, with longer lists, more items would need to be encoded to deeper levels and therefore the beneficial effects of noise evident on the recency portion of the curve (which remains the same length) would exert a smaller influence on the overall free recall score as the list becomes longer and eventually, if noise adversely affects semantic processing, overall free recall performance in noise would tend to become worse. Indeed, Daee and Wilding, using a list length of 40 items found the mean number of words recalled (free recall) was significantly worse in 85dB noise than in quiet.

Thus while the majority of the evidence would appear to support the proposal of less deep levels of coding under high arousal any adequate theoretical account of the relationship between arousal and memory must explain the fact that the effects of noise are partially determined by the nature of the task.

Thus far, the explanations of noise effects assigned them to the learning stage of memory. Nevertheless, Schwartz (see Eysenck, 1976) proposed that the differential effects of arousal on memory for phonemically and semantically related material are due to processes operating at retrieval, even though the paradigms he used only involved the manipulation of arousal at the time of input. In the present study, the effects of noise during recall were examined and indeed the results suggest that noise during this period exerts a beneficial effect upon immediate short-term memory after the sequential presentation of items. This beneficial effect had a tendency to be greater after the presentation of items had been in relative quiet than when the items had also been presented in noise. It was proposed that noise during recall encouraged subjects to adopt a different retrieval strategy, the reconstructive strategy rather than the scanning strategy adopted in quiet. Different types of coding are considered optimal for the different types of retrieval strategy (Jacoby, 1974), which could account for the tendency of performance to be better in QN than in NN, since recall by the reconstruction retrieval mode is considered to be superior after deeper levels of processing. Since the effects of noise during recall have been relatively unexplored there is little evidence to support the present findings. Nevertheless, since noise effects are generally considered to be mediated via an arousal mechanism, limited support for an improvement in recall under conditions of high arousal during recall comes from the work of Pessin (1933) and Bourne (1955).

Following work which demonstrated a relationship between level of activation, extraversion - introversion and retrieval from semantic memory (Eysenck, 1974) Eysenck attempted to extend the generality of his findings by manipulating arousal level by presenting subjects with white noise during some recall and recognition trials. He found that high arousal tended to facilitate performance involving retrieval from dominant sources, but to lead to slower responding on those trials necessitating the retrieval of non-dominant information. He concludes that while relatively few studies have concentrated on the effects of arousal at the time of test it has clearly been established that such effects do exist. Eysenck (1976) hypothesises that the optimal level of arousal (conjointly determined by item and subject arousal) which is required for successful performance on a retention test is directly related to the accessibility or functional dominance of the appropriate response. More precisely, high arousal has the effect of biassing the subject's search process toward readily accessible stored information to a greater extent than is the case with lower levels of arousal. The functional dominance of a response is the degree of accessibility in the search process of that response in a given retrieval context. The results indicating improved performance with noise during recall obtained in Experiments 4, 4A and 5 could thus be interpreted in terms of Eysenck's hypothesis if one assumes that the responses required were dominant responses, which is likely since recall was intentional. However, it is unclear why noise level during presentation of the items should exert an influence on the obtained beneficial effect of noise during recall. It is also not clear how Eysenck's views could be incorporated with those of Craik and his colleagues suggesting the possibility of two retrieval strategies, unless biassing the subject's search towards readily accessible stored information enables the subject to use the retrieval information as the basis for the reconstruction of the original event more efficiently.

The possibility that noise affects retrieval strategy is also suggested by the data on recall order in the present experiment. When subjects recalled in noise rather than in quiet there was a tendency for more responses to be recorded serially, a finding which would also support the suggestion that noise during recall encourages subjects to adopt the reconstructive mode of retrieval rather than the backward scanning mode.

The original aim of the thesis was that it was an empirical study to provide further understanding of the apparently inconsistent results already obtained on the effects of noise on short-term memory. The results obtained seem to suggest that noise is more likely to affect certain types of memory task than others. For the immediate recall of relatively short lists of words or digits, noise tends to exert a slight beneficial effect when ordered recall is required. This effect appears to be independent of rate of presentation or list length.

Throughout the experiments, a consistent tendency was noted for noise to result in improved recall in the recency portion of the serial position curve, while the reverse tended to be the case on early serial positions, although this latter effect tended to be smaller. Many of the reported noise and memory experiments fail to give serial position data and thus it is difficult to compare them. The present study also suggests that noise does not differentially affect recall and recognition. Of the parameters examined, the introduction of a short delay before recall exerted the most notable effect. Since many of the experiments noted in Table 2 employed 'immediate' recall, two minutes after the presentation, their obtained detrimental effects of noise would be expected. Another factor which also determined the nature of possible noise effects was the timing of the noise. Noise during recall enhanced performance particularly after the presentation of items in relative quiet. Thus the present study would seem to have provided some insight into the apparently inconsistent results previously reported, although results obtained with other methods of arousal manipulation suggest that the modality of presentation may be an important factor in the effects of high arousal on short-term memory performance. Patrick, Davies and Cumberbatch (1974) reviewed a number of studies on the effects of time of day on such tasks. Results showing superior performance in the afternoon i.e. under conditions of high arousal, were obtained in studies employing visual presentation of relatively short lists of items for ordered recall. However, the studies suggesting superior performance during the morning employed auditory presentation, although it must be noted that some of these also employed longer lists of items to be remembered. While it is difficult to employ auditory presentation when examining noise effects nevertheless the possibility of modality effects needs to be considered when interpreting noise effects in terms of high arousal. Research on the effects of time of day has also yielded similar results to those obtained in the present study, suggesting that high arousal differentially affects the recency and primacy areas of the serial position curve and performance after immediate or delayed recall.

Thus most of the evidence at present appears to be consistent with the view that noise during the sequential presentation of items reduces the 'depth' of processing of to-be-remembered material. Since ordered recall performance in quiet after noise during presentation tends to be better than that after quiet, it is suggested that noise tends to facilitate phonemic coding. Such a view would be consistent with the enhanced recency effect observed after noise. Similarly it was suggested that noise during presentation impairs deeper levels of processing since when subjects expect recall to be delayed it has been suggested that they are attempting to encode all the items in a list semantically in order to survive the delay (Jacoby and Bartz, 1972) and delayed recall in quiet is significantly worse after noise during the presentation of items. However, it was pointed out that it is possible that noise merely prevents deeper levels of coding rather than impairs such coding. The experiments presented here do not distinguish between these two interpretations and it may well prove useful to examine the effects of noise upon an orienting task in which the subject has to answer a particular question about a word which is presented tachistoscopically. The questions asked cover the structural to the semantic aspects of the stimulus. Indeed these tasks have been employed in the recent work of Craik and his colleagues (Craik and Tulving, 1976) in their attempt to explain memory in terms of levels of processing.

The results of Experiment 6 suggested that noise during simultaneous presentation encourages subjects to organise their material differently and it was proposed that this could involve subjects temporally grouping their data in a more regular way. Underwood (1976) considers that the grouping of a string of random digits is related to the rhythmical representation of the string in 'active verbal memory' or 'phonemic memory'. Thus the enhanced recency effect obtained in noise and attributed to the beneficial effects of noise upon phonemic encoding may be mediated by the regular grouping of items in a list in noise, since the grouping of items in a list is one of the variables known to affect recency (Herriot, 1974). The grouping of items is also known to differentially affect the recall of item and order information. The effects of noise upon differently grouped items, presented both simultaneously and sequentially would thus seem to be an area worthy of further examination.

In the present experiments, the subjects were free to recall the items in any order so long as they attempted to record each item in its correct box. While experiments 4, 5 and 6 suggest that noise during recall encourages subjects to record their responses serially more often than is the case in Q, the material to be learned in these experiments comprised short lists of digits. For longer lists of more meaningful material which were adopted in Experiments 1, 2 and 3, no data on the order of responses were obtained. Nevertheless, following the recent work of Daee and Wilding (1977) which has suggested possible differential effects of noise upon sequential and positional learning it would appear desirable in future experiments to control, or at least take account of, differences in response order.

Some of the components of memory tasks which have been examined appear not to interact with the effects of noise e.g. presentation rate, list length. However, in the case of presentation rate, the material to be learned comprised 9-digit sequences. With such material it is possible that subjects are unlikely to code the material semantically for any of the presentation rates used and therefore possible differential effects of noise upon phonemic and semantic coding would be unlikely to occur. With longer lists of meaningful material, Shulman (1970) obtained a significant interaction between type of encoding and presentation rate, with the slower rate resulting in an increased probability of encoding a word semantically. Thus it would seem desirable to examine the effects of noise upon presentation rate using more meaningful material. Similarly, the effects of type of presentation were only examined using short lists of digits and more research employing meaningful material that possibly lends itself to more grouping would seem desirable.

The results of Experiments 4, 4A, 5 and 6 however, seem to provide support for the existence of two modes of retrieval, and that noise during recall encourages subjects to adopt a different retrieval strategy to that adopted in quiet. It was proposed that when recall is in noise, subjects adopt the reconstructive mode of retrieval whereas in quiet, they adopt the backward scanning strategy. Craik and his colleagues suggest that in control conditions while subjects normally adopt the scanning mode of retrieval for immediate recall, when recall is delayed they may well adopt the other strategy. If this is the case, then in the delayed recall condition of Experiment 2, even though subjects recalled in quiet, they would adopt the reconstructive mode of retrieval and hence the obtained result would be expected since semantic processing is considered beneficial for this mode of retrieval.

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APPENDICES

APPENDIX 1

Raw data for Experiment 1

a) Ordered recall

LL8

SP		1	2	3	4	5	6	7	8
NQ	M1			✓	✓	✓		✓	✓
	2	✓	✓		✓		✓		✓
	3	✓		✓	✓	✓			
	4	✓			✓	✓	✓	✓	✓
	5	✓	✓	✓		✓			
	6	✓	✓	✓					
	7	✓	✓	✓	✓			✓	
	8	✓	✓	✓					
	F1	✓	✓	✓	✓		✓	✓	✓
	2	✓	✓	✓	✓		✓		✓
	3	✓	✓	✓	✓	✓		✓	✓
	4		✓	✓					
	5	✓	✓	✓			✓		
	6	✓	✓	✓		✓			✓
	7	✓	✓		✓	✓			
	8	✓	✓					✓	✓
QQ	M1	✓	✓				✓		
	2	✓	✓	✓	✓	✓			
	3	✓	✓			✓		✓	
	4		✓			✓			✓
	5	✓	✓	✓	✓		✓		
	6	✓	✓						✓
	7	✓	✓	✓	✓				
	8	✓	✓	✓	✓		✓		
	F1	✓	✓	✓	✓	✓		✓	
	2	✓	✓					✓	
	3	✓	✓	✓	✓	✓	✓		
	4	✓	✓	✓	✓		✓		
	5	✓	✓	✓	✓				✓
	6	✓	✓					✓	
	7	✓		✓	✓				✓
	8	✓	✓		✓				

LL12

SP		1	2	3	4	5	6	7	8	9	10	11	12
NQ	M1	✓	✓	✓	✓								
	2	✓	✓	✓	✓	✓							
	3	✓	✓	✓									✓
	4	✓	✓							✓	✓		✓
	5	✓	✓	✓								✓	
	6	✓	✓									✓	✓
	7	✓	✓		✓								✓
	8	✓			✓								
	F1	✓	✓	✓	✓					✓		✓	✓
	2	✓	✓		✓	✓							
	3	✓	✓	✓		✓				✓	✓		✓
	4	✓		✓		✓							✓
	5		✓							✓	✓		✓
	6	✓	✓							✓	✓		✓
	7	✓	✓	✓	✓			✓					
	8	✓	✓				✓	✓		✓	✓	✓	✓
QQ	M1	✓	✓									✓	
	2	✓	✓	✓	✓							✓	✓
	3	✓	✓										
	4	✓	✓					✓			✓	✓	
	5	✓	✓	✓						✓			
	6	✓	✓	✓	✓	✓	✓						
	7	✓	✓	✓									✓
	8	✓	✓								✓	✓	✓
	F1	✓	✓	✓								✓	✓
	2	✓	✓	✓	✓								✓
	3	✓	✓	✓	✓								
	4	✓	✓				✓						
	5	✓	✓										
	6	✓	✓	✓									✓
	7	✓		✓									
	8	✓	✓										

LL16

SP		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
NQ	M1	✓	✓	✓	✓	✓	✓	✓									
	2	✓	✓									✓					
	3							✓				✓	✓	✓	✓	✓	✓
	4	✓	✓							✓							
	5	✓	✓														
	6	✓	✓	✓			✓										
	7	✓															
	8	✓					✓								✓	✓	✓
	F1	✓	✓	✓	✓	✓	✓	✓								✓	✓
	2	✓	✓									✓	✓				
	3	✓	✓								✓						✓
	4	✓	✓			✓	✓	✓	✓		✓					✓	✓
	5	✓														✓	✓
	6	✓	✓	✓				✓									
	7				✓	✓	✓										
	8	✓	✓								✓						
QQ	M1		✓	✓													
	2	✓	✓														
	3	✓		✓													
	4	✓					✓	✓	✓								
	5	✓	✓		✓												
	6	✓	✓	✓							✓		✓		✓	✓	✓
	7	✓	✓	✓	✓												✓
	8	✓	✓	✓	✓					✓					✓	✓	✓
	F1	✓	✓		✓												
	2	✓	✓	✓	✓												
	3	✓	✓	✓													✓
	4	✓								✓		✓			✓		✓
	5	✓	✓	✓						✓							✓
	6	✓	✓	✓													✓
	7	✓		✓													✓
	8																✓

b) Free recall

LL8

SP		1	2	3	4	5	6	7	8
NQ	M1			✓	✓	✓		✓	✓
	2	✓	✓		✓	✓	✓		✓
	3	✓	✓	✓	✓	✓		✓	
	4	✓			✓	✓	✓	✓	✓
	5	✓	✓	✓		✓			✓
	6	✓	✓	✓	✓	✓	✓	✓	✓
	7	✓	✓	✓	✓		✓	✓	
	8	✓	✓	✓		✓	✓		
	F1	✓	✓	✓	✓		✓	✓	✓
	2	✓	✓	✓	✓		✓	✓	✓
	3	✓	✓	✓	✓	✓		✓	✓
	4		✓	✓			✓	✓	✓
	5	✓	✓	✓	✓	✓	✓	✓	
	6	✓	✓	✓	✓	✓	✓	✓	✓
	7	✓	✓		✓	✓	✓	✓	✓
	8	✓	✓	✓		✓		✓	✓
QQ	M1	✓	✓		✓		✓	✓	✓
	2	✓	✓	✓	✓	✓			✓
	3	✓	✓	✓		✓	✓	✓	
	4		✓		✓	✓	✓		✓
	5	✓	✓	✓	✓		✓	✓	
	6	✓	✓				✓	✓	✓
	7	✓	✓	✓	✓	✓		✓	
	8	✓	✓	✓	✓		✓	✓	✓
	F1	✓	✓	✓	✓	✓		✓	✓
	2	✓	✓		✓	✓	✓	✓	✓
	3	✓	✓	✓	✓	✓	✓	✓	
	4	✓	✓	✓	✓		✓	✓	✓
	5	✓	✓	✓	✓		✓		✓
	6	✓	✓		✓		✓	✓	
	7	✓	✓	✓	✓	✓	✓		✓
	8	✓	✓			✓		✓	

LL12

SP		1	2	3	4	5	6	7	8	9	10	11	12
NQ	M1	✓	✓	✓	✓			✓				✓	✓
	2	✓	✓	✓	✓	✓			✓			✓	✓
	3	✓	✓	✓								✓	✓
	4	✓	✓							✓	✓	✓	✓
	5	✓	✓	✓	✓			✓	✓	✓		✓	
	6	✓	✓	✓				✓		✓		✓	✓
	7	✓	✓		✓						✓		✓
	8	✓			✓			✓	✓	✓	✓	✓	
	F1	✓	✓	✓	✓					✓	✓	✓	✓
	2	✓	✓		✓	✓	✓	✓	✓		✓		
	3	✓	✓	✓		✓		✓		✓	✓	✓	✓
	4	✓		✓	✓	✓			✓		✓	✓	✓
	5		✓		✓	✓				✓	✓		✓
	6	✓	✓	✓	✓					✓	✓		✓
	7	✓	✓	✓	✓		✓	✓				✓	
	8	✓	✓		✓	✓	✓	✓		✓	✓	✓	✓
QQ	M1	✓	✓			✓	✓					✓	
	2	✓	✓	✓	✓							✓	✓
	3	✓	✓	✓				✓	✓	✓	✓		
	4	✓	✓					✓			✓	✓	✓
	5	✓	✓	✓		✓				✓		✓	
	6	✓	✓	✓	✓	✓	✓				✓		
	7	✓	✓	✓	✓			✓				✓	✓
	8	✓	✓						✓		✓	✓	✓
	F1	✓	✓	✓	✓	✓		✓			✓	✓	
	2	✓	✓	✓	✓		✓					✓	✓
	3	✓	✓	✓	✓					✓	✓	✓	✓
	4	✓	✓				✓		✓		✓	✓	✓
	5	✓	✓	✓		✓				✓			✓
	6	✓	✓	✓	✓		✓	✓			✓		✓
	7	✓	✓	✓		✓		✓				✓	✓
	8	✓	✓			✓		✓			✓	✓	

LL16

SP		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
NQ	M1	✓	✓	✓	✓	✓	✓	✓							✓		
	2	✓	✓		✓							✓	✓			✓	
	3			✓	✓			✓	✓		✓	✓	✓	✓	✓	✓	✓
	4	✓	✓							✓				✓	✓	✓	
	5	✓	✓	✓	✓				✓	✓	✓				✓		
	6	✓	✓	✓			✓			✓	✓	✓		✓	✓		✓
	7	✓		✓	✓							✓		✓			
	8	✓	✓				✓					✓	✓		✓	✓	✓
	F1	✓	✓	✓	✓	✓	✓	✓				✓	✓	✓		✓	✓
	2	✓	✓		✓					✓		✓	✓				✓
	3	✓	✓		✓		✓	✓	✓		✓	✓	✓	✓	✓		✓
	4	✓	✓			✓	✓	✓	✓		✓	✓		✓		✓	✓
	5	✓											✓	✓	✓	✓	✓
	6	✓	✓	✓	✓			✓	✓	✓							
	7	✓		✓	✓	✓	✓			✓	✓	✓		✓			✓
	8	✓	✓		✓		✓	✓		✓	✓	✓		✓		✓	✓
QQ	M1		✓	✓	✓	✓	✓	✓		✓							
	2	✓	✓				✓	✓					✓		✓		
	3	✓		✓	✓		✓			✓		✓			✓		
	4	✓			✓		✓	✓	✓				✓		✓		✓
	5	✓	✓		✓		✓			✓	✓			✓			
	6	✓	✓	✓			✓				✓		✓		✓	✓	✓
	7	✓	✓	✓	✓					✓	✓	✓		✓	✓		✓
	8	✓	✓	✓	✓	✓	✓			✓			✓		✓	✓	✓
	F1	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓		✓	✓	
	2	✓	✓	✓	✓					✓	✓				✓	✓	✓
	3	✓	✓	✓				✓		✓	✓						✓
	4	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
	5	✓	✓	✓						✓		✓		✓		✓	✓
	6	✓	✓	✓				✓					✓	✓			✓
	7	✓		✓	✓	✓	✓			✓	✓	✓					✓
	8	✓	✓		✓						✓	✓	✓		✓	✓	✓

c) Location scores (% correct)

	NOISE			QUIET		
LL	8	12	16	8	12	16
M1	40	71.5	37.5	50	20	42.8
2	16.7	25	66.7	55.7	50	50
3	100	33.3	18.2	50	42.9	71.4
4	33.3	33.3	33.3	40	83.5	12.5
5	40	75	75	66.7	16.7	57.1
6	50	28.6	50	60	51.2	55.5
7	33.3	0	20	0	42.9	60
8	40	42.9	62.5	42.8	42.9	54.5
F1	42.8	75	41.7	71.4	25	75
2	42.8	37.5	42.9	42.8	57.2	22.2
3	0	22.2	33.3	66.7	75	71.4
4	80	50	36.4	28.6	42.9	50
5	14.3	42.9	33.3	33.3	66.7	12.5
6	0	14.3	28.5	40	37.5	71.4
7	71.4	14.3	70	42.8	42.9	44.4
8	16.7	60	45.4	75	66.7	11.1

Table 55a

Anova Noise x list length x Sex for ordered recall scores (Experiment 1)

Source	SS	df	MS	F
Noise (N)	27.27	1	27.27	2.83^{+}
List length (LL)	703.31	2	351.65	36.55^{**}
Sex (S)	13.55	1	13.55	1.41
N x LL	5.17	2	2.58	<1
N x S	31.39	1	31.39	3.26^{+}
LL x S	5.97	2	2.98	<1
N x LL x S	20.76	2	10.38	1.08
Within cell	808.55	84	9.62	

Table 55b

Anova Noise x List length x Sex for free recall scores (Experiment 1)

Source	SS	df	MS	F
Noise (N)	10.63	1	10.63	1.42
List length (LL)	512.18	2	256.09	34.28^{**}
Sex (S)	89.26	1	89.26	11.95^{**}
N x LL	9.15	2	4.57	<1
N x S	4.90	1	4.90	<1
LL x S	0.40	2	0.20	<1
N x LL x S	0.70	2	0.35	<1
Within cell	627.45	84	7.47	

Table 56

Anova Noise x List length x Sex (Location scores)

Source	SS	df	MS	F
Noise (N)	65.64	1	65.64	2.37
List length (LL)	5.96	2	2.98	< 1
Sex (S)	4.15	1	4.15	< 1
N x LL	10.81	2	5.40	< 1
N x S	22.56	1	22.56	< 1
LL x S	29.50	2	14.75	< 1
N x LL x S	36.30	2	18.15	< 1
Within Cell	2,325.38	84	27.68	

APPENDIX 2

Raw data for Experiment 2

a) Ordered recall Trial 1 only

	Immediate				Delay		
NOISE SP	1-4	5-8	9-12		1-4	5-8	9-12
M1	3	1	1	M1	2	0	0
2	3	1	3	2	1	1	0
3	3	0	3	3	2	0	0
4	2	0	1	4	2	0	0
5	1	0	1	5	3	0	1
6	0	0	0	6	2	0	0
7	4	2	1	7	1	0	2
8	1	1	0	8	2	0	0
9	2	0	1	9	2	0	0
10	2	0	1	10	4	0	0
F1	3	0	2	F1	2	0	0
2	3	0	0	2	1	1	1
3	4	0	0	3	1	0	0
4	1	0	2	4	0	0	0
5	3	0	1	5	3	0	0
6	4	0	2	6	2	0	0
7	3	0	0	7	2	2	0
8	4	0	0	8	2	0	0
9	3	0	2	9	1	1	0
10	2	1	0	10	3	0	0

QUIET	Immediate 1-4	Immediate 5-8	Immediate 9-12		Delay 1-4	Delay 5-8	Delay 9-12
M1	3	0	0	M1	3	0	0
2	2	1	3	2	3	1	0
3	1	0	1	3	4	0	0
4	2	0	0	4	4	1	0
5	4	0	2	5	0	0	1
6	4	1	0	6	1	1	0
7	2	0	0	7	3	0	0
8	2	0	1	8	2	0	0
9	1	0	0	9	2	0	0
10	3	0	2	10	2	0	0
F1	2	0	0	F1	4	0	0
2	2	0	0	2	2	0	0
3	1	0	1	3	4	0	0
4	1	0	2	4	1	0	0
5	3	0	1	5	3	3	2
6	2	1	0	6	1	0	2
7	2	1	3	7	3	0	0
8	2	0	2	8	3	0	0
9	1	4	1	9	2	0	0
10	3	0	0	10	3	0	1

b) Free recall Trial 1 only

NOISE SP	Immediate 1-4	5-8	9-12		Delay 1-4	5-8	9-12
M1	4	2	1	M1	4	1	1
2	3	1	3	2	3	1	0
3	3	0	4	3	3	1	0
4	4	2	1	4	3	1	1
5	2	1	1	5	3	1	1
6	3	2	1	6	3	0	0
7	4	2	2	7	2	1	3
8	2	2	1	8	3	2	1
9	2	2	1	9	4	1	2
10	3	3	2	10	4	1	1
F1	3	2	2	F1	2	1	1
2	3	4	0	2	1	1	1
3	4	2	3	3	1	3	2
4	3	0	2	4	3	2	1
5	3	2	2	5	3	2	2
6	4	2	3	6	3	0	1
7	3	1	2	7	2	3	0
8	4	1	1	8	2	3	2
9	4	0	2	9	1	3	0
10	2	3	1	10	4	1	1

QUIET	Immediate 1-4	5-8	9-12		Delay 1-4	5-8	9-12
M1	4	3	1	M1	4	0	0
2	2	1	3	2	3	1	2
3	1	3	1	3	4	0	3
4	3	1	1	4	4	2	1
5	4	0	2	5	0	2	3
6	4	2	1	6	1	1	1
7	2	1	1	7	3	1	2
8	2	2	2	8	2	2	1
9	1	0	2	9	4	2	1
10	3	2	2	10	2	0	2
F1	3	3	2	F1	4	1	0
2	3	1	1	2	2	1	2
3	3	0	1	3	4	0	1
4	2	0	2	4	3	3	0
5	3	1	1	5	3	3	3
6	2	2	1	6	3	3	3
7	4	1	3	7	3	1	0
8	3	0	3	8	4	4	2
9	1	4	1	9	2	0	1
10	4	2	2	10	3	0	2

c) Ordered recall - Trials 3 - 12

NOISE	Immediate 1-4	Immediate 5-8	Immediate 9-12		Delay 1-4	Delay 5-8	Delay 9-12
M1	40	31	26	M1	5	1	0
2	8	5	27	2	14	3	6
3	21	2	30	3	13	2	0
4	12	0	18	4	10	0	0
5	13	4	14	5	13	8	8
6	19	9	22	6	9	0	3
7	25	3	21	7	19	4	1
8	8	14	27	8	23	2	3
9	17	0	18	9	20	7	11
10	30	14	31	10	20	4	4
F1	10	3	19	F1	10	5	3
2	13	1	15	2	18	3	7
3	14	1	1	3	8	1	1
4	22	7	15	4	23	3	2
5	17	6	25	5	4	7	1
6	23	11	20	6	11	2	9
7	14	7	30	7	17	1	2
8	13	2	27	8	14	4	8
9	25	27	37	9	15	8	13
10	18	13	26	10	15	12	11

	Immediate				Delay		
QUIET	1-4	5-8	9-12		1-4	5-8	9-12
M1	17	4	18	M1	5	1	0
2	16	8	29	2	14	3	6
3	11	1	27	3	13	2	0
4	13	5	19	4	10	0	0
5	11	1	12	5	13	8	8
6	7	4	0	6	9	0	3
7	23	5	23	7	19	4	1
8	16	1	6	8	23	2	3
9	23	1	18	9	20	7	11
10	16	2	14	10	20	4	4
F1	26	8	21	F1	10	5	3
2	20	12	28	2	18	3	7
3	27	6	20	3	8	1	1
4	5	2	21	4	23	3	2
5	13	5	28	5	4	7	1
6	16	5	27	6	11	2	9
7	15	6	19	7	17	1	2
8	22	5	6	8	14	4	8
9	21	13	15	9	15	8	13
10	14	3	19	10	15	12	11

d) Free recall Trials 3 - 12

NOISE	Immediate 1-4	5-8	9-12		Delay 1-4	5-8	9-12
M1	40	37	37	M1	16	15	15
2	12	11	31	2	18	7	12
3	28	6	32	3	18	4	10
4	18	4	21	4	18	7	13
5	17	12	19	5	17	19	13
6	24	14	27	6	11	4	10
7	28	13	25	7	23	16	9
8	13	21	32	8	24	7	12
9	19	12	23	9	27	18	20
10	32	16	31	10	23	8	10
F1	18	14	28	F1	13	12	11
2	16	9	22	2	25	17	18
3	15	14	16	3	12	12	14
4	27	13	22	4	30	11	8
5	19	11	28	5	12	16	21
6	27	16	29	6	20	12	17
7	15	13	35	7	22	10	14
8	15	8	31	8	16	7	14
9	25	27	37	9	20	12	19
10	21	15	28	10	24	23	23

QUIET	Immediate 1-4	5-8	9-12		Delay 1-4	5-8	9-12
M1	40	37	37	M1	25	2	6
2	12	11	31	2	19	18	16
3	28	6	32	3	31	23	22
4	18	4	21	4	20	8	17
5	17	12	19	5	22	10	13
6	24	14	27	6	23	5	12
7	28	13	25	7	18	11	14
8	13	21	32	8	21	14	22
9	19	12	23	9	30	13	9
10	32	16	31	10	23	10	16
F1	18	14	28	F1	29	10	18
2	16	9	22	2	28	9	12
3	15	14	16	3	21	9	10
4	27	13	22	4	20	17	16
5	19	11	28	5	18	15	20
6	27	16	29	6	18	18	14
7	15	13	35	7	25	14	4
8	15	8	31	8	30	11	12
9	25	27	37	9	20	12	13
10	21	15	28	10	17	14	14

Table 57

Anova - Noise x Serial position x Retention interval x Sex (ordered recall) (Trial 1)

Source	SS	df	MS	F
Between subjects	65.65	79		
Noise (N)	0.15	1	0.15	< 1
Retention interval (Rl)	6.01	1	6.01	7.61**
Sex (S)	0.15	1	0.15	< 1
N x Rl	2.02	1	2.02	2.56+
N x S	0.15	1	0.15	< 1
Rl x S	0.02	1	0.02	< 1
Nx Rl x S	0.42	1	0.42	< 1
Subj. w gps.	56.73	72	0.79	
Within subjects	302.00	160		
Serial position (SP)	177.02	2	88.51	118.01**
N x SP	0.18	2	0.09	< 1
SP x Rl	5.07	2	2.53	3.37*
SP x S	0.03	2	0.01	< 1
N x SP x Rl	3.10	2	1.55	2.07
N x SP x S	1.97	2	0.98	< 1
SP x Rl x S	0.85	2	0.42	< 1
N x SP x Rl x S	6.11	2	3.05	4.07*
SP x Subj. w gps.	107.67	144	0.75	

Table 58

Anova - Noise x Serial position x Retention interval x Sex (Free recall Trial 1)

Source	SS	df	MS	F
Between subjects	66.3	79		
Noise (N)	0.1	1	0.1	<1
Retention interval (Rl)	3.5	1	3.5	4.32^{*}
Sex (S)	0.71	1	0.71	1
N x Rl	3.05	1	3.05	3.76^{+}
N x S	0.11	1	0.11	<1
Rl x S	0.01	1	0.01	<1
N x Rl x S	0.32	1	0.32	<1
Subj. w gps.	58.50	72	0.81	
Within subjects	272.00	160		
Serial position (SP)	100.83	2	50.41	46.25^{**}
N x SP	1.44	2	0.72	<1
SP x Rl	1.04	2	0.52	<1
SP x S	1.43	2	0.71	<1
N x SP x Rl	0.69	2	0.34	<1
N x SP x S	2.43	2	1.21	1.11
SP x Rl x S	4.43	2	2.21	2.03
N x SP x Rl x S	2.71	2	1.35	1.24
SP x Subj. w gps.	157.00	144	1.09	

Table 59

Anova - Noise x Serial position x Retention interval x Sex (Ordered recall Trials 3-12)

Source	SS	df	MS	F
Between subjects	7,402.87	79		
Noise (N)	0.04	1	0.04	<1
Retention interval (Rl)	2,001.04	1	2,001.04	30.71**
Sex (S)	36.04	1	36.04	<1
N x Rl	501.68	1	501.68	7.70**
N x S	78.21	1	78.21	1.20
Rl x S	0.21	1	0.21	<1
N x Rl x S	95.02	1	95.02	1.46
Subj. w gps.	4,690.63	72	65.15	
Within subjects	11,692.60	160		
Serial position (SP)	5,286.93	2	2,643.46	111.35**
N x SP	135.66	2	67.83	2.86^{+}
SP x Rl	2,787.76	2	1,393.88	58.71**
SP x S	23.72	2	11.86	<1
N x SP x Rl	14.11	2	7.05	<1
N x SP x S	13.02	2	6.51	<1
SP x Rl x S	6.62	2	3.31	<1
N x SP x Rl x S	5.71	2	2.85	<1
SP x Subj. w gps.	3,419.07	144	23.74	

Table 60

Anova - Noise x Serial position x Retention interval x Sex (Free Recall Trials 3-12)

Source	SS	df	MS	F
Between subjects	5,024.53	79		
Noise (N)	0.03	1	0.03	<1
Retention interval (Rl)	1,396.83	1	1,396.83	29.20**
Sex (S)	6.33	1	6.33	<1
N x Rl	82.85	1	82.85	1.73
N x S	0.02	1	0.02	<1
Rl x S	22.22	1	22.22	<1
N x Rl x S	71.48	1	71.48	1.49
Subj. w gps.	3,444.77	72	47.84	
Within subjects	8,558.13	160		
Serial position (SP)	3,424.29	2	1,712.14	72.03**
N x SP	233.11	2	116.55	4.90**
SP x Rl	1,332.31	2	666.15	28.02**
SP x S	82.91	2	41.45	1.74
N x SP x Rl	25.19	2	12.59	<1
N x SP x S	13.42	2	6.71	<1
SP x Rl x S	8.92	2	4.46	<1
N x SP x Rl x S	14.65	2	7.32	<1
SP x Subj. w gps.	3,423.33	144	23.77	

Word lists for Experiment 2

List 1	List 3	List 5
TRIED	PLANE	PAUSE
STUFF	MATCH	WHEAT
DROVE	COULD	ROUND
BIRTH	FENCE	STRIP
RANGE	SMALL	LARGE
SWORD	FOUND	BRUSH
GREET	WRITE	SPARE
BOUND	PLATE	GROWN
STATE	START	SHALL
FALSE	THING	COURT
PORCH	STYLE	BLOCK
STILL	FLOOD	LEAVE

List 2	List 4	List 6
STAGE	FIGHT	CRIME
TROOP	TRAIL	STAND
SOUND	PRICE	PRIZE
FLAME	SHEEP	FORCE
QUICK	FLOAT	HOUSE
CHEEK	LEAST	WOUND
HENCE	GREEN	BEAST
CRIED	RIGHT	SWING
STAIR	TRICK	PLACE
HEART	BROAD	SHINE
MARCH	STEAM	LAUGH
GRAND	LEARN	STOOD

List 7

SLAVE
WHOLE
BLESS
KNIFE
TREAT
BRAVE
STAMP
WEIGH
SHELL
WORST
CHARM
GREAT

List 9

MIGHT
SCORE
ROUGH
PROUD
SPENT
FLOUR
YIELD
KNOCK
BLIND
CHAIN
SAINT
REACH

List 11

SPORT
PRINT
TRIBE
SHEET
FRONT
SMART
GRACE
ROUTE
NOISE
CREAM
BRAIN
SCALE

List 8

SHORT
THINK
HORSE
PLANT
GUEST
SHARP
BREAD
WRONG
CHEAP
SHAME
GRAVE
TRACE

List 10

SKIRT
TWICE
CLERK
HEARD
SWELL
THROW
LIGHT
FAITH
STEEL
SERVE
LOOSE
MONTH

List 12

CLOTH
SPEED
TEETH
BEACH
MEANT
WATCH
SPEAK
SHOOT
PRIDE
CLOCK
NURSE
SPITE

APPENDIX 3

Raw data for Experiment 3

a) Trial 1 only

	NOISE				QUIET		
	1-4	5-8	9-12		1-4	5-8	9-12
M1	2	4	3	M1	3	4	3
2	4	2	4	2	4	2	3
3	4	4	4	3	3	1	2
4	3	1	3	4	3	3	3
5	3	3	0	5	4	2	2
F1	4	2	3	F1	4	3	2
2	4	1	3	2	4	2	0
3	3	2	4	3	4	4	3
4	3	3	4	4	2	4	3
5	3	3	3	5	4	2	2

b) Trials 3-12

	NOISE				QUIET		
	1-4	5-8	9-12		1-4	5-8	9-12
M1	17	17	34	M1	34	23	26
2	35	33	37	2	28	21	30
3	32	32	38	3	35	18	29
4	28	12	32	4	32	25	35
5	25	18	37	5	17	19	26
F1	31	25	33	F1	29	19	32
2	33	28	31	2	31	30	37
3	39	33	35	3	38	27	39
4	34	27	35	4	24	25	31
5	26	32	37	5	32	23	21

Table 61

Anova - Noise x Serial position x Sex (Recognition Trial 1)

Source	SS	df	MS	F
Between subjects	1,047.27	19		
Noise (N)	81.67	1	81.67	1.59
Sex (S)	141.07	1	141.07	2.74
N x S	2.40	1	2.40	<1
Subj. w gps.	822.13	16	51.38	
Within subjects	1,460.67	40		
Serial position (SP)	733.63	2	366.82	20.12**
N x SP	47.23	2	23.62	1.29
SP x S	49.23	2	24.62	1.35
N x SP x S	47.10	2	23.55	1.29
SP x Subj. w gps.	583.47	32	18.23	

Table 62

Anova - Noise x Serial position x Sex (Trials 3-12)

Source	SS	df	MS	F
Between subjects	16.07	19		
Noise (N)	0.26	1	0.26	<1
Sex (S)	0.06	1	0.06	<1
N x S	0.01	1	0.01	<1
Subj. w gps.	15.74	16	0.98	
Within subjects	45.33	40		
Serial position (SP)	7.60	2	3.80	3.97*
N x SP	3.34	2	1.67	1.74
SP x S	0.14	2	0.07	<1
N x SP x S	3.59	2	1.79	1.87
SP x Subj. w gps.	30.66	32	0.96	

Word lists for Experiment 3

List 1	List 2	List 3
GREET	SOUND	WORTH
BOUND	SLEPT	FLOOD
FAULT	GRAND	WRITE
STATE	WORLD	STICK
SENSE	BREAK	TRAIN
FALSE	QUICK	BUILT
PORCH	CRIED	THING
STUFF	RAISE	SLEEP
SWORD	WORSE	STYLE
CHILD	STAIR	FENCE
BUILD	CROWN	BROOK
MOUNT	STAGE	WHEEL
RANGE	VOICE	CROSS
SHAKE	YOUNG	FRUIT
TRACK	TROOP	SHAVE
FRESH	MARCH	FOUND
THREW	PRESS	PROVE
CATCH	HEART	GRADE
STILL	CHEEK	SMALL
OUGHT	GUIDE	PLATE
SPOKE	GROUP	MATCH
TRIED	GRAIN	START
DROVE	FLAME	COULD
BIRTH	HENCE	PLANE

List 4

LEARN
PEACE
SHOUT
GREEN
JUDGE
SHIRT
STEAM
FIGHT
PLAIN
FIELD
TRUTH
PRICE
DWELL
BROAD
TRIAL
SHEEP
FLOAT
TRICK
CRUSH
WASTE
RIGHT
LEAST
DRESS
SHIELD

List 5

BRIEF
CHOSE
COURT
LARGE
SHALL
STRIP
WHEAT
SPEND
KNOWN
SPARE
CHAIR
GUARD
SWEEP
PAUSE
SMILE
ROUND
BRUSH
TRUST
GROWN
STORE
BLOCK
CLIMB
GRASS
LEAVE

List 6

HOUSE
FRAME
BEAST
CRIME
BRICK
DEPTH
CAUSE
STAND
LAUGH
SHINE
FORCE
PRIZE
MOUTH
STOOD
PLACE
WOUND
SWING
SHOWN
FLOOR
DOUBT
GRANT
SPACE
FEAST
REIGN

List 7	List 8	List 9
STAMP	CLEAN	YIELD
WEIGH	SHORT	GOOSE
SLAVE	GRAVE	BOARD
WHOLE	PLANT	BRING
CHARM	WRONG	POINT
BLESS	BREAD	MIGHT
SHELL	BURST	WROTE
TREAT	TRACE	BLIND
WORST	CHEAP	SCORE
STOCK	COULD	WOULD
FLEET	SHARP	CHAIN
CHECK	BLAME	FLOCK
PEARL	TEACH	ROUGH
KNIFE	SHOOK	PROUD
STIFF	QUEEN	SPENT
BLACK	SMOKE	STONE
GREAT	TASTE	STARE
BRAVE	GUEST	SAINT
CEASE	CHIEF	DANCE
MIDST	LODGE	FLOUR
PAINT	SPOIL	COUNT
DRINK	THINK	REACH
FIXED	SHAME	CLASS
TOUCH	HORSE	KNOCK

List 10	List 11	List 12
LIGHT	GUESS	COAST
PROOF	NOISE	SPEED
THANK	BRAIN	SPITE
CLERK	GRACE	TEETH
FAITH	CLEAR	SHAPE
SHORE	SCALE	PIECE
HEARD	PRINT	BEACH
SERVE	FRONT	MEANT
TRADE	YOUTH	QUITE
SWELL	TRIBE	CLOCK
STEEL	BROKE	HASTE
POUND	SMART	CLOTH
THROW	DRAWN	NURSE
CHEER	CEASE	SPELL
TWICE	SHEET	PRIDE
LOOSE	STORM	TRUNK
CRUEL	CREAM	WATCH
BROWN	ROUTE	DREAM
MONTH	CRACK	CROWD
SHADE	SIGHT	THICK
SKIRT	DRIVE	SHOOT
BLOOD	SPORT	CLAIM
CHASE	CLOSE	SWEET
SLOPE		

APPENDIX 4

Raw data for Experiment 4

a) Number digits correct for trial 1 only

SP	NN 1-3	NN 4-6	NN 7-9
M1	2	0	3
2	3	0	1
3	3	1	0
4	3	3	2
5	3	3	2
6	3	3	2
7	0	0	0
8	3	3	3
9	3	3	2
10	3	3	3
F1	3	2	0
2	3	3	3
3	2	0	1
4	3	3	2
5	2	0	1
6	3	1	0
7	2	0	0
8	0	3	0
9	0	0	0
10	0	0	0

	QQ 1-3	QQ 4-6	QQ 7-9
M1	0	1	0
2	3	3	2
3	0	0	0
4	2	0	1
5	2	0	0
6	0	0	0
7	3	1	2
8	0	0	0
9	2	0	1
10	3	2	2
F1	3	3	2
2	3	1	0
3	0	0	0
4	3	3	2
5	3	0	1
6	0	2	0
7	2	0	0
8	1	0	3
9	2	0	0
10	0	0	0

	NQ 1-3	NQ 4-6	NQ 7-9
M1	3	1	2
2	3	3	3
3	0	2	2
4	1	0	0
5	2	2	3
F1	1	0	1
2	0	0	0
3	0	0	0
4	3	1	2
5	1	0	0

	QN 1-3	QN 4-6	QN 7-9
M1	1	0	1
2	3	1	0
3	0	0	0
4	3	3	2
5	3	3	1
F1	3	3	3
2	3	1	0
3	3	1	0
4	3	3	2
5	1	0	0

b) Number of responses recorded in the order 1-9

NN	Trials 6-15	Trials 16-25	Trials 26-35	Trials 36-45	Trials 46-55
M1	9	7	8	6	9
2	9	8	6	6	8
3	10	10	7	10	10
4	10	9	10	10	10
5	9	7	3	0	0
6	10	9	9	9	10
7	6	4	9	9	10
8	10	10	10	10	10
9	10	10	10	10	10
10	2	1	0	0	0
F1	2	2	0	3	0
2	10	10	7	9	9
3	10	10	10	10	10
4	8	10	4	2	9
5	5	3	4	3	1
6	9	8	10	10	7
7	10	3	9	5	8
8	6	3	9	10	10
9	5	2	2	1	1
10	8	9	8	10	10

QQ	Trials 6-15	Trials 16-25	Trials 26-35	Trials 36-45	Trials 46-55
M1	2	2	3	6	4
2	0	4	1	0	2
3	6	8	5	7	5
4	2	5	7	6	6
5	10	10	10	10	10
6	10	10	10	8	7
7	3	3	8	4	6
8	9	8	4	7	10
9	2	2	4	3	5
10	0	0	1	0	0
F1	7	7	5	3	0
2	2	2	1	3	0
3	1	2	0	2	0
4	4	4	0	2	8
5	7	4	0	0	0
6	1	3	1	1	1
7	10	10	9	10	10
8	0	1	0	0	1
9	3	3	4	3	2
10	3	1	1	6	1

NQ	Trials 6-15	Trials 16-25	Trials 26-35	Trials 36-45	Trials 46-55
M1	10	10	10	10	8
2	5	7	6	9	8
3	10	9	10	10	9
4	3	0	0	2	0
5	4	9	5	9	9
F1	9	9	5	5	5
2	5	1	1	0	0
3	0	0	0	0	0
4	10	9	10	10	10
5	10	10	10	10	10

QN	Trials 6-15	Trials 16-25	Trials 26-35	Trials 36-45	Trials 46-55
M1	4	5	6	2	1
2	8	7	9	8	7
3	9	10	10	10	10
4	7	9	8	10	9
5	10	3	0	0	0
F1	10	10	10	10	10
2	2	4	6	2	6
3	9	10	6	9	10
4	0	0	1	0	0
5	3	1	3	3	4

c) <u>Number digits correct for trials 6-55</u>

<u>NN</u>	Trials 6-15			Trials 16-25			Trials 26-35			Trials 36-45			Trials 46-55		
SP	1-3	4-6	7-9	1-3	4-6	7-9	1-3	4-6	7-9	1-3	4-6	7-9	1-3	4-6	7-9
M1	12	5	12	10	9	10	17	4	16	17	5	10	16	8	14
2	12	4	14	14	4	10	20	7	8	28	17	7	24	16	11
3	22	14	5	27	21	10	19	15	9	27	11	7	26	18	8
4	26	23	13	29	26	17	26	24	19	22	24	18	27	28	21
5	30	27	18	29	21	14	26	24	23	24	25	27	28	27	26
6	23	24	18	29	27	21	21	21	24	22	27	25	29	24	22
7	25	23	11	14	11	15	16	10	6	21	18	13	27	28	12
8	30	28	26	30	29	27	30	28	28	30	30	30	30	30	30
9	30	24	12	30	30	15	29	28	16	26	14	15	30	25	13
10	29	27	28	30	29	21	28	29	20	22	21	25	22	23	25
F1	6	8	14	12	7	16	21	9	14	21	14	12	17	9	15
2	27	25	12	28	25	16	27	23	25	28	27	18	25	24	21
3	18	10	9	26	15	13	15	16	11	23	15	10	25	13	10
4	18	14	15	19	15	20	21	13	22	19	16	23	25	18	18
5	13	10	15	21	18	21	16	17	22	18	20	22	18	21	22
6	27	21	12	25	19	16	22	22	12	24	23	17	17	19	15
7	16	5	4	12	5	16	14	7	10	16	14	20	17	8	13
8	26	16	14	23	19	18	28	27	24	29	27	20	29	29	25
9	17	10	12	17	9	16	21	10	12	21	16	25	19	9	22
10	22	8	8	25	14	19	19	11	15	26	14	12	25	10	13

<u>NQ</u>	Trials 6-15			Trials 16-25			Trials 26-35			Trials 36-45			Trials 46-55		
SP	1-3	4-6	7-9	1-3	4-6	7-9	1-3	4-6	7-9	1-3	4-6	7-9	1-3	4-6	7-9
M1	18	12	7	20	11	5	20	11	9	21	11	8	23	10	9
2	17	17	24	18	21	15	22	20	23	19	18	23	23	23	28
3	29	23	11	29	24	20	30	25	18	27	20	20	29	15	16
4	13	7	17	16	10	27	10	8	26	10	17	25	17	19	28
5	18	13	18	24	19	10	19	19	16	27	15	10	25	19	15
F1	11	7	17	19	8	16	17	16	25	22	16	20	16	16	22
2	22	11	10	20	12	25	19	9	20	23	19	18	25	23	21
3	2	20	26	5	22	27	11	21	29	11	25	30	8	22	27
4	29	23	16	26	18	17	27	23	19	22	12	12	27	20	14
5	20	8	10	15	6	16	15	7	9	19	8	13	16	6	11

QQ	Trials 6-15			Trials 16-25			Trials 26-35			Trials 36-45			Trials 46-55		
SP	1-3	4-6	7-9	1-3	4-6	7-9	1-3	4-6	7-9	1-3	4-6	7-9	1-3	4-6	7-9
M1	10	11	12	9	6	13	17	11	1	16	10	13	19	8	16
2	15	9	25	22	21	20	19	24	24	30	28	20	23	24	23
3	14	14	11	19	11	11	14	10	13	14	12	14	9	5	7
4	22	14	6	18	12	7	21	16	8	21	17	7	19	16	10
5	24	12	4	13	8	7	26	19	20	24	18	14	22	16	16
6	25	15	8	23	13	6	23	12	12	23	9	10	22	13	7
7	16	9	18	10	5	10	20	6	9	13	6	11	10	4	19
8	19	6	12	15	9	11	21	8	15	28	21	23	25	22	16
9	18	16	24	17	17	15	20	14	13	12	11	20	17	14	10
10	29	25	8	26	22	16	24	18	21	29	21	20	29	25	25
F1	30	22	18	20	20	17	24	19	21	24	21	21	22	16	22
2	22	13	14	18	10	6	23	18	10	28	21	13	30	20	9
3	15	19	27	20	14	24	18	27	30	19	24	29	16	25	27
4	30	26	7	29	26	11	29	19	12	23	17	16	28	22	13
5	20	10	9	15	13	20	11	14	28	11	18	22	16	20	26
6	26	11	20	22	15	10	22	7	10	21	16	14	21	23	17
7	23	16	9	23	14	7	22	12	9	18	9	6	22	8	7
8	17	19	21	26	28	29	28	29	30	25	30	30	28	30	30
9	20	11	15	16	12	19	16	15	14	14	12	19	18	9	19
10	27	22	12	26	24	11	24	16	6	18	14	9	25	25	11

QN	Trials 6-15			Trials 16-25			Trials 26-35			Trials 36-45			Trials 46-55		
	1-3	4-6	7-9	1-3	4-6	7-9	1-3	4-6	7-9	1-3	4-6	7-9	1-3	4-6	7-9
M1	20	19	27	24	17	23	20	19	22	17	22	26	16	17	25
2	25	20	14	29	20	19	30	19	13	24	18	7	26	20	16
3	29	22	16	30	30	24	29	29	28	28	24	18	29	26	22
4	22	21	17	25	21	12	22	20	17	26	26	13	24	25	15
5	30	30	29	27	25	25	30	30	30	30	30	25	26	25	20
F1	30	30	30	28	29	28	30	27	30	29	27	27	27	25	27
2	25	14	18	23	18	21	30	22	23	25	18	15	26	20	23
3	21	10	13	26	14	15	21	18	25	23	20	20	27	14	13
4	7	20	30	10	23	29	18	19	28	21	24	28	12	25	30
5	13	2	12	19	11	16	11	8	18	16	9	22	11	8	10

Table 63

Anova - Noise x Serial position x Sex (Trial 1)

Source	SS	df	MS	F
Noise (N)	10.00	3	3.33	1.12
Sex (S)	6.47	1	6.47	2.18
N x S	16.67	3	5.56	1.88
Subj. w gps.	154.08	52	2.96	
Serial position (SP)	20.41	2	10.20	15.00**
N x SP	6.54	6	1.09	1.60
SP x S	0.93	2	0.46	< 1
N x SP x S	0.67	6	0.11	< 1
SP x Subj. w gps.	71.32	104	0.68	

Table 64

Anova - Noise x Blocks x Sex (Number order 1-9)

Source	SS	df	MS	F
Noise (N)	319.16	3	106.39	1.93
Sex (S)	143.14	1	143.14	2.59
N x S	10.14	3	3.38	<1
Subj. w gps.	2,871.74	52	55.22	
Serial position (SP)	15.47	4	3.87	1.24
N x SP	15.81	12	1.32	<1
SP x S	3.87	4	0.97	<1
N x SP x S	55.03	12	4.58	1.47
SP x Subj. w gps.	649.96	208	3.12	

Table 65

Anova - Noise x Blocks x Sex x Serial position

Source	SS	df	MS	F
Noise (N)	2,353.91	3	784.64	2.72+
Sex (S)	126.46	1	126.46	<1
N x S	1,152.71	3	384.24	1.33
Subj. w gps.	14,997.27	52	288.41	
Blocks (B)	483.44	4	120.86	6.57**
N x B	281.21	12	23.43	1.27
B x S	77.04	4	19.26	1.05
N x B x S	191.83	12	15.98	<1
B x Subj. w gps.	3,826.73	208	18.40	
Serial position (SP)	2,675.60	2	1,337.80	14.71**
N x SP	580.09	6	96.68	1.06
S x SP	484.84	2	242.42	2.66+
N x S x SP	334.03	6	55.67	<1
SP x Subj. w gps.	9,458.67	104	90.95	
B x SP	90.38	8	11.30	1.10
N x B x SP	114.79	24	4.78	<1
B x S x SP	41.02	8	5.13	<1
N x B x S x SP	158.61	24	6.61	<1
B x SP x Subj. w gps.	4,274.73	416	10.27	

9-digit sequences for Experiment 4

249867153

964315782

495263178

248739615

681395742

953716428

539168274

123495768

946837125

492153786

529681347

192378456

725619834

896257143

632418795

769182354

347869215

685923174

341678592

169324875

621837594

957216843

824695371

695718423

237694185

984216573

652871394

823619745

674198523

751942638

439527816

513984267

864572391

285934167

647583921

259347168

381594726

962783145

835176492

126384975

715243896

459187632

542318976

763142589

127358694

572914836

469251378

148672935

923517684

362485791

489721536

528476319

317289456

238796541

574138296

937281564

741352986

934267851

465731982

976412835

APPENDIX 4A

Raw data for Experiment 4A

a) Ordered recall - Trial 1 only

NN	1-4	5-8	9-12
M1	4	0	0
2	3	0	2
3	1	2	1
4	2	1	0
5	0	0	0
F1	3	1	2
2	4	0	2
3	2	0	2
4	1	1	0
5	3	1	3

QN	1-4	5-8	9-12
M1	1	2	4
2	3	0	3
3	0	0	3
4	4	0	2
5	0	0	2
F1	1	0	0
2	2	0	1
3	3	2	2
4	3	0	1
5	0	0	0

b) Free recall - Trial 1 only

NN	1-4	5-8	9-12
M1	4	0	1
2	3	0	2
3	1	3	2
4	4	2	0
5	3	2	0
F1	3	1	3
2	4	0	3
3	3	2	2
4	2	2	2
5	3	2	3

QN	1-4	5-8	9-12
M1	1	2	4
2	3	2	3
3	2	2	3
4	4	0	2
5	1	2	2
F1	2	3	2
2	2	1	1
3	3	3	2
4	3	1	4
5	1	1	3

c) Ordered recall - Trials 3-12

NN	1-4	5-8	9-12
M1	21	8	10
2	19	8	20
3	16	25	36
4	21	2	26
5	30	2	3
F1	25	15	17
2	30	9	28
3	21	18	28
4	19	11	24
5	14	11	27

QN	1-4	5-8	9-12
M1	30	31	36
2	23	7	31
3	26	13	25
4	13	2	25
5	20	0	15
F1	25	12	23
2	15	1	16
3	34	9	25
4	29	14	34
5	11	18	19

d) Free recall - Trials 3-12

NN	1-4	5-8	9-12
M1	25	11	14
2	21	17	24
3	16	26	36
4	28	10	28
5	33	9	10
F1	28	24	22
2	33	13	29
3	23	22	30
4	24	26	32
5	20	17	29

QN	1-4	5-8	9-12
M1	32	33	38
2	26	14	32
3	28	14	31
4	22	11	27
5	24	7	19
F1	32	25	30
2	19	9	19
3	34	16	26
4	32	23	35
5	19	22	28

Table 66

Anova - Noise x Serial position x Sex (Trial 1 only - ordered recall)

Source	SS	df	MS	F
Noise (N)	0.87	3	0.29	<1
Sex (S)	0.00	1	0.00	<1
N x S	7.20	3	2.40	1.97
Subj. w gps.	63.40	52	1.22	
Serial position (SP)	81.71	2	40.85	45.39**
N x SP	10.74	6	1.79	1.99+
SP x S	2.07	2	1.03	1.14
N x SP x S	15.14	6	2.52	2.80*
SP x Subj. w gps.	93.20	104	0.90	

Table 67

Anova - Noise x Serial position x Sex (Trial 1 only - Free recall)

Source	SS	df	MS	F
Noise (N)	1.80	3	0.60	<1
Sex (S)	1.13	1	1.13	1.82
N x S	1.93	3	0.64	1.03
Subj. w gps.	32.20	52	0.62	
Serial position (SP)	40.02	2	20.01	16.96^{**}
N x SP	13.94	6	2.32	1.97+
SP x S	0.73	2	0.36	<1
N x SP x S	5.94	6	0.99	<1
SP x Subj. w gps.	122.40	104	1.18	

Table 68

Anova - Noise x Serial position x Sex (Trials 3-12 - Ordered recall)

Source	SS	df	MS	F
Noise (N)	842.35	3	280.78	2.96*
Sex (S)	44.09	1	44.09	<1
Nx S	202.50	3	67.50	<1
Subj. w gps.	4,929.57	52	94.80	
Serial position (SP)	5,441.59	2	2,720.79	72.78**
N x SP	80.37	6	13.39	<1
SP x S	14.87	2	7.43	<1
N x SP x S	68.90	6	11.48	<1
SP x Subj. w gps.	3,887.43	104	37.38	

Table 69

Anova - Noise x Serial position x Sex (Trials 3-12 - Free recall)

Source	SS	df	MS	F
Noise (N)	406.40	3	135.47	2.07
Sex (S)	49.16	1	49.16	<1
N x S	163.41	3	54.47	<1
Subj. w gps.	3,399.80	52	65.38	
Serial position (SP)	3,347.87	2	1,673.93	54.08**
N x SP	198.83	6	33.14	1.07
SP x S	72.50	2	36.25	1.17
N x SP x S	63.90	6	10.65	<1
SP x Subj. w gps.	3,218.90	104	30.95	

APPENDIX 5

Raw data for Experiment 5

a) Recall data for Trial 1 only

	1/S			2/S			3/S		
NN	1-3	4-6	7-9	1-3	4-6	7-9	1-3	4-6	7-9
M1	3	3	3	3	2	0	3	0	0
2	1	1	2	1	1	2	1	0	0
3	3	1	1	3	1	2	2	1	0
4	2	1	2	3	2	2	3	1	1
5	3	3	3	2	1	1	3	1	0
6	3	3	3	3	1	0	3	2	0
7	3	3	3	3	3	3	3	3	2
8	3	2	1	3	1	3	2	1	0
9	3	3	1	3	3	2	3	1	1
10	0	0	1	0	1	0	2	1	0
11	3	0	1	3	1	0	0	0	0
F1	3	3	2	3	3	0	3	3	1
2	0	0	1	3	1	0	3	1	0
3	3	0	3	3	2	0	3	3	2
4	3	1	2	3	1	1	1	1	0
5	3	2	2	2	2	3	1	0	3
6	3	2	0	3	1	0	2	1	1
7	3	0	0	2	1	1	1	0	0
8	1	1	2	3	3	2	3	1	0
9	1	1	3	1	2	3	3	2	0
10	3	2	0	2	0	2	1	1	0
11	2	2	2	3	3	3	1	0	2
12	3	1	0	1	0	1	2	0	2

NQ	1/S 1-3	1/S 4-6	1/S 7-9	2/S 1-3	2/S 4-6	2/S 7-9	3/S 1-3	3/S 4-6	3/S 7-9
M1	3	3	1	2	0	1	3	2	3
2	1	0	1	3	1	2	1	0	0
3	3	0	1	2	1	0	0	0	0
4	3	3	3	3	3	2	1	0	0
5	1	0	2	3	2	2	0	0	0
F1	3	0	0	0	0	2	1	0	0
2	1	0	0	2	0	1	1	0	1
3	1	0	1	0	3	1	0	0	1
4	3	3	1	3	2	1	3	2	2
5	1	0	0	3	2	0	3	1	0

QN	1/S 1-3	1/S 4-6	1/S 7-9	2/S 1-3	2/S 4-6	2/S 7-9	3/S 1-3	3/S 4-6	3/S 7-9
M1	2	0	1	1	0	0	0	0	0
2	3	3	3	3	3	1	3	2	0
3	1	2	0	0	0	0	3	1	1
4	2	1	1	3	2	1	1	0	0
5	3	2	1	3	0	0	0	0	0
F1	3	3	0	3	3	1	0	0	2
2	3	2	0	3	3	3	0	0	3
3	3	0	2	0	1	3	3	1	1
4	3	2	2	2	0	3	1	0	3
5	3	3	3	3	0	0	1	1	3

QQ	1/S 1-3	1/S 4-6	1/S 7-9	2/S 1-3	2/S 4-6	2/S 7-9	3/S 1-3	3/S 4-6	3/S 7-9
M1	1	0	0	2	0	0	3	2	0
2	2	1	2	3	2	1	0	0	0
3	3	3	0	3	1	0	0	0	3
4	3	0	0	1	0	0	3	2	0
5	3	1	0	0	0	0	1	2	2
6	3	3	2	3	2	0	2	1	0
7	1	1	1	3	1	1	3	0	0
8	3	3	1	3	3	3	3	1	1
9	3	3	3	3	0	0	1	0	0
10	3	3	1	3	3	1	1	0	1
11	3	2	1	1	1	1	2	0	2
F1	2	1	0	3	2	1	3	0	0
2	3	0	1	3	2	0	3	1	0
3	2	0	0	2	0	0	3	3	2
4	3	2	0	3	2	0	1	0	0
5	2	1	0	3	2	2	3	0	0
6	0	1	1	1	1	3	3	2	2
7	3	1	0	1	0	0	2	0	0
8	1	1	0	3	0	0	1	0	0
9	2	0	2	3	1	3	3	0	1
10	3	2	3	2	2	2	3	0	1
11	2	2	1	2	0	1	3	0	0
12	2	0	0	3	3	3	0	0	0

b) Number of responses recorded in the order 1-9

NN	1/S	2/S	3/S
M1	22	3	17
2	15	13	18
3	24	25	24
4	4	13	13
5	4	10	9
6	21	21	18
7	24	24	25
8	25	25	25
9	25	25	25
10	25	25	24
11	11	13	18
F1	25	25	25
2	25	25	25
3	19	19	15
4	20	11	11
5	24	25	25
6	21	19	18
7	25	25	25
8	1	4	1
9	4	4	9
10	3	1	6
11	23	21	20
12	25	25	25

NQ	1/S	2/S	3/S
M1	1	4	4
2	18	20	20
3	23	24	23
4	16	14	17
5	11	5	0
F1	5	5	5
2	25	24	25
3	8	19	15
4	25	24	25
5	21	25	25

QN	1/S	2/S	3/S
M1	5	4	3
2	0	0	1
3	13	16	20
4	24	23	25
5	8	9	10
F1	15	15	17
2	1	1	3
3	6	1	11
4	6	7	3
5	18	19	21

QQ	1/S	2/S	3/S
M1	24	24	23
2	0	0	1
3	19	19	21
4	24	24	25
5	22	23	23
6	19	23	23
7	23	18	23
8	1	1	3
9	24	25	24
10	5	3	8
11	5	3	2
F1	22	19	7
2	11	13	12
3	25	22	19
4	14	5	5
5	22	18	16
6	19	21	23
7	2	1	4
8	24	24	21
9	14	19	20
10	1	16	17
11	0	0	1
12	16	25	24

c) Recall data for Trials 6-80

NN	1/S 1-3	1/S 4-6	1/S 7-9	2/S 1-3	2/S 4-6	2/S 7-9	3/S 1-3	3/S 4-6	3/S 7-9
M1	72	66	36	69	66	29	70	51	38
2	67	57	56	59	51	62	58	36	55
3	54	40	31	58	22	26	58	22	14
4	53	51	50	61	47	43	45	36	36
5	65	56	54	56	47	42	63	48	46
6	51	42	26	53	39	15	44	18	12
7	75	74	74	69	73	73	67	65	69
8	66	44	41	68	57	35	62	51	37
9	73	73	74	73	71	68	72	70	61
10	35	27	47	24	11	39	26	14	25
11	61	51	46	66	50	35	63	40	36
F1	62	50	38	61	46	42	59	33	35
2	46	35	20	34	20	15	45	21	12
3	73	71	63	65	66	69	64	28	23
4	65	58	38	69	42	38	54	27	38
5	48	47	46	45	45	52	44	38	44
6	49	20	25	57	18	22	40	21	11
7	33	12	65	31	15	62	51	21	37
8	70	66	50	71	68	44	71	61	33
9	53	20	39	64	27	33	59	20	19
10	54	56	68	59	41	39	50	36	24
11	51	56	72	40	54	71	45	40	61
12	32	18	38	33	11	20	39	21	14

	1/S			2/S			3/S		
NQ	1-3	4-6	7-9	1-3	4-6	7-9	1-3	4-6	7-9
M1	60	63	67	42	57	61	43	37	44
2	53	25	20	55	27	22	43	17	18
3	69	63	38	66	57	28	64	45	28
4	63	55	48	66	62	43	67	38	33
5	51	42	50	58	41	54	53	28	54
F1	54	36	25	48	26	14	55	23	14
2	60	52	28	65	46	24	53	32	18
3	34	34	44	48	49	37	42	33	29
4	57	56	47	55	31	17	48	27	25
5	65	61	43	54	30	21	58	36	18

	1/S			2/S			3/S		
QN	1-3	4-6	7-9	1-3	4-6	7-9	1-3	4-6	7-9
M1	50	32	31	51	25	33	53	23	32
2	72	74	71	63	69	67	69	65	61
3	26	10	27	34	8	25	39	13	13
4	67	60	31	69	56	29	64	40	17
5	59	46	55	50	25	50	44	21	41
F1	62	59	38	62	54	41	58	34	28
2	54	55	72	54	53	69	43	24	48
3	69	66	70	66	54	64	60	59	50
4	61	55	52	57	45	58	58	38	50
5	65	58	47	53	47	33	61	48	13

QQ	1/S 1-3	1/S 4-6	1/S 7-9	2/S 1-3	2/S 4-6	2/S 7-9	3/S 1-3	3/S 4-6	3/S 7-9
M1	34	15	24	47	34	57	41	20	30
2	59	39	33	49	40	27	44	25	18
3	62	39	34	72	47	28	63	32	31
4	31	43	53	28	31	29	34	29	32
5	61	57	64	59	53	55	46	38	49
6	66	51	30	60	46	31	68	52	32
7	64	42	26	68	28	15	46	21	13
8	65	47	41	70	56	43	54	43	39
9	61	46	21	64	46	12	61	31	10
10	64	47	26	70	52	33	51	33	25
11	50	46	55	60	39	37	63	26	20
F1	61	41	22	62	46	21	59	26	16
2	45	13	21	41	21	23	39	15	21
3	71	48	26	65	40	27	67	33	13
4	72	68	30	63	54	22	58	44	17
5	65	25	12	60	33	19	58	20	12
6	65	60	44	60	43	30	62	54	34
7	47	18	21	40	13	14	41	8	18
8	34	34	54	50	33	51	60	39	50
9	48	40	51	29	33	57	37	25	51
10	61	65	72	48	55	65	40	40	45
11	62	43	26	57	37	31	55	37	33
12	62	64	35	64	61	42	68	52	42

Table 70

Anova - Noise x Rate x Sex x Serial position (Trial 1 only)

Source	SS	df	MS	F
Noise (N)	10.93	3	3.64	1.54
Sex (S)	0.14	1	0.14	<1
N x S	13.43	3	4.48	1.90
Subj. w gps.	137.04	58	2.36	
Rate (R)	35.50	2	17.75	12.59**
N x R	6.05	6	1.01	<1
R x S	7.24	2	3.62	2.57+
N x R x S	5.01	6	0.83	<1
R x Subj. w gps.	163.79	116	1.41	
Serial position (SP)	106.84	2	53.42	70.29**
N x SP	6.40	6	1.07	1.41
S x SP	2.44	2	1.22	1.60
N x S x SP	8.42	6	1.40	1.84
SP x Subj. w gps.	88.52	116	0.76	
R x SP	2.57	4	0.64	<1
N x R x SP	11.07	12	0.92	1.15
R x S x SP	5.22	4	1.30	1.62
N x R x S x SP	11.07	12	0.92	1.15
R x SP x Subj. w gps.	186.53	232	0.80	

Table 71

Anova - Noise x Rate x Sex (Number recorded order 1-9)

Source	SS	df	MS	F
Noise (N)	1,359.15	3	453.05	2.07
Sex (S)	9.26	1	9.26	<1
N x S	294.96	3	98.32	<1
Subj. w gps.	12,666.17	58	218.38	
Rate (R)	18.23	2	9.11	<1
N x R	29.44	6	4.91	<1
R x S	4.38	2	2.19	<1
N x R x S	39.81	6	6.63	<1
R x Subj. w gps.	1,104.93	116	9.52	

Table 72

Anova - Noise x Rate x Sex x Serial position (Trials 6-80)

Source	SS	df	MS	F
Noise (N)	2,840.65	3	946.88	< 1
Sex (S)	319.95	1	319.95	< 1
N x S	5,672.33	3	1,890.78	1.84
Subj. w gps.	59,556.60	58	1,026.83	
Rate (R)	8,093.44	2	4,046.72	59.24**
N x R	228.93	6	38.16	< 1
R x S	152.14	2	76.07	1.11
N x R x S	500.49	6	83.41	1.22
R x Subj. w gps.	7,923.90	116	68.31	
Serial position (SP)	29,427.58	2	14,713.79	47.84**
N x SP	1,731.93	6	288.65	< 1
S x SP	9.53	2	4.76	< 1
N x S x SP	1,076.57	6	179.43	< 1
SP x Subj. w gps.	35,677.40	116	307.56	
R x SP	1,658.78	4	414.69	14.63**
N x R x SP	474.18	12	39.51	1.39
R x S x SP	131.61	4	32.90	1.16
N x R x S x SP	379.67	12	31.64	1.11
R x SP x Subj. w gps.	6,576.40	232	28.35	

Table 73

Spearman rank correlation coefficients for extroversion score x number of digits correct

	NN	NQ	QN	QQ
Rate 1/S	-.10	0.30	0.64*	0.02
Rate 2/S	-.03	0.21	0.50	-0.06
Rate 3/S	-0.06	0.32	0.43	-0.12
	(ns=23)	(n=10)	(n=10)	(n=23)

Table 74

Spearman rank correlation coefficients for extroversion score x number order 1-9

	NN	NQ	QN	QQ
Rate 1/S	-.11	.88**	-.58*	.18
Rate 2/S	-.07	.77**	-.39	.10
Rate 3/S	-.17	.66*	-.49	.07
	(n=23)	(n=10)	(n=10)	(n=23)

APPENDIX 6

Raw data for Experiment 6

a) Recall data for Trial 1 only

NN	1-3	4-6	7-9	QQ	1-3	4-6	7-9
M1	3	0	2	M1	3	3	0
2	3	2	2	2	3	0	2
3	3	3	3	3	3	3	1
4	3	3	0	4	3	2	0
5	3	3	2	5	3	2	0
6	3	3	1	6	3	2	2
7	2	3	3	7	1	3	3
8	3	3	3	8	2	1	1
9	3	2	2	9	3	3	2
10	3	2	2	10	3	1	0
F1	3	3	2	F1	3	1	1
2	2	0	0	2	3	3	3
3	3	2	2	3	3	3	0
4	3	3	2	4	3	3	3
5	3	3	3	5	3	3	1
6	3	2	2	6	3	3	3
7	3	3	3	7	3	3	2
8	0	0	2	8	3	3	0
9	3	1	1	9	3	3	3
10	3	3	3	10	3	3	3

NQ	1-3	4-6	7-9	QN	1-3	4-6	7-9
M1	3	1	1	M1	3	2	0
2	3	3	3	2	1	1	0
3	3	3	3	3	3	3	3
4	3	2	2	4	3	2	1
5	3	1	2	5	3	1	0
F1	3	3	3	F1	2	2	0
2	3	3	3	2	3	2	0
3	2	0	0	3	3	3	3
4	3	3	3	4	3	2	2
5	0	2	3	5	3	2	1

b) <u>Number of responses recorded in the order 1-9</u>

NN	Trials 6-15	Trials 16-25	Trials 26-35	Trials 36-45	Trials 46-55
M1	10	9	10	8	8
2	7	10	8	9	9
3	10	10	10	10	9
4	10	8	10	10	10
5	10	10	10	10	10
6	8	9	10	5	0
7	9	9	10	10	10
8	10	10	10	10	10
9	9	10	10	10	10
10	9	8	10	10	8
F1	3	1	0	0	0
2	5	3	5	4	4
3	10	10	10	10	10
4	10	10	10	9	10
5	10	10	10	10	10
6	10	9	10	10	10
7	10	10	10	10	10
8	10	10	10	10	9
9	10	10	9	10	10
10	10	10	10	10	10

QQ	Trials 6-15	Trials 16-25	Trials 26-35	Trials 36-45	Trials 46-55
M1	10	10	9	10	9
2	3	8	8	9	10
3	10	8	9	10	10
4	10	10	9	9	10
5	10	8	10	10	9
6	9	10	10	10	10
7	3	2	3	3	4
8	10	10	10	10	10
9	9	9	9	10	10
10	6	8	10	10	9
F1	8	10	9	10	10
2	10	10	10	10	10
3	10	10	10	10	10
4	10	10	10	10	10
5	8	9	10	7	6
6	10	10	10	10	10
7	4	3	6	6	6
8	10	10	10	10	9
9	9	10	10	10	10
10	9	3	5	7	6

NQ	Trials 6-15	Trials 16-25	Trials 26-35	Trials 36-45	Trials 46-55
M1	4	9	8	8	9
2	10	10	10	10	10
3	10	9	10	10	9
4	7	8	6	1	5
5	6	9	9	8	9
F1	10	10	10	10	10
2	6	8	5	10	9
3	4	5	8	8	7
4	9	9	9	10	10
5	5	8	9	7	7

QN	Trials 6-15	Trials 16-25	Trials 26-35	Trials 36-45	Trials 46-55
M1	10	6	8	5	5
2	10	10	10	10	10
3	10	9	10	10	10
4	10	10	10	10	10
5	10	10	10	10	10
F1	10	10	10	10	10
2	10	10	10	10	10
3	10	10	10	8	10
4	6	8	9	9	9
5	10	10	10	10	10

c) <u>Number of digits correct for trials 6-55</u>

NN	Trials 6-15			Trials 16-25			Trials 26-35			Trials 36-45			Trials 46-55		
SP	1-3	4-6	7-9	1-3	4-6	7-9	1-3	4-6	7-9	1-3	4-6	7-9	1-3	4-6	7-9
M1	29	21	15	29	15	18	28	22	19	28	16	22	23	13	15
2	30	18	16	30	13	10	30	21	12	28	22	10	30	18	13
3	29	26	22	30	26	21	29	23	20	28	27	23	25	21	22
4	29	16	16	29	20	23	28	27	23	29	26	16	22	21	12
5	28	27	27	28	24	22	27	22	19	28	28	26	30	25	22
6	23	18	14	30	27	19	30	29	20	29	30	21	28	25	26
7	29	27	28	29	28	28	30	29	27	28	27	29	30	29	27
8	30	26	22	30	29	29	29	28	28	30	30	30	29	26	27
9	29	24	18	29	22	20	30	25	20	30	20	19	28	27	13
10	30	23	19	28	20	27	30	28	26	28	28	25	30	27	26
F1	26	25	24	25	19	26	30	27	22	30	30	30	28	29	30
2	29	25	21	29	17	21	26	21	21	27	16	17	25	19	19
3	26	27	21	30	25	22	30	24	24	27	28	25	30	26	25
4	28	24	18	27	21	17	30	23	26	26	21	18	28	22	16
5	27	25	20	30	23	21	29	27	24	30	26	22	30	29	21
6	30	27	29	30	30	29	30	28	23	30	30	29	28	30	30
7	30	30	30	28	29	26	30	29	30	28	29	26	30	30	29
8	29	21	18	24	16	14	28	24	19	27	22	19	29	19	20
9	28	19	18	28	23	27	30	27	19	30	27	28	26	26	21
10	30	28	28	29	28	23	29	28	27	30	28	25	29	28	28

NQ	Trials 6-15			Trials 16-25			Trials 26-35			Trials 36-45			Trials 46-55		
SP	1-3	4-6	7-9	1-3	4-6	7-9	1-3	4-6	7-9	1-3	4-6	7-9	1-3	4-6	7-9
M1	30	28	22	28	27	27	30	30	30	26	25	23	28	22	21
2	29	29	23	30	28	17	30	27	22	30	26	23	30	30	20
3	29	28	29	26	29	27	29	28	26	30	28	24	28	28	26
4	29	24	20	28	25	25	27	25	29	27	25	28	23	19	23
5	21	13	16	22	12	7	22	12	10	17	14	13	28	21	13
F1	23	20	18	26	23	17	29	26	15	28	26	17	27	19	19
2	25	15	18	25	15	15	26	15	18	23	23	12	23	18	17
3	21	9	17	25	19	19	28	20	19	27	22	15	24	21	23
4	29	26	21	30	29	27	30	27	26	28	26	26	26	25	23
5	30	13	23	18	16	18	30	16	17	27	20	20	27	20	17

QQ	Trials 6-15			Trials 16-25			Trials 26-35			Trials 26-45			Trials 46-55		
SP	1-3	4-6	7-9	1-3	4-6	7-9	1-3	4-6	7-9	1-3	4-6	7-9	1-3	4-6	7-9
M1	30	25	8	29	24	20	28	26	16	27	27	10	30	26	16
2	29	20	23	30	27	27	30	29	27	27	23	27	29	24	22
3	26	22	20	28	18	24	28	19	19	25	23	23	30	27	28
4	25	18	13	29	28	23	29	21	18	28	21	13	28	23	12
5	29	17	12	28	21	24	30	26	26	28	21	18	30	22	14
6	30	22	21	30	26	21	28	24	27	29	23	17	29	25	21
7	16	24	25	23	23	21	21	25	24	18	23	24	21	19	17
8	30	22	18	29	22	18	28	19	18	27	16	11	27	20	16
9	28	12	10	28	22	14	29	20	13	29	17	21	27	12	11
10	30	28	25	30	25	27	29	19	18	30	27	22	28	19	22
F1	27	11	9	22	16	10	24	19	7	26	21	14	25	13	5
2	30	28	25	30	26	18	30	25	26	30	27	21	29	24	22
3	26	20	10	18	16	9	25	16	9	30	22	6	27	10	6
4	30	27	28	28	27	26	28	19	23	30	26	20	29	25	29
5	22	25	22	27	17	15	27	22	10	22	15	12	25	24	25
6	29	27	19	30	24	15	30	29	23	30	30	17	30	26	25
7	26	12	17	30	21	22	27	22	14	30	21	22	29	21	15
8	28	13	8	28	20	3	25	19	8	29	16	12	30	26	10
9	30	23	27	29	26	21	29	26	27	28	28	27	30	29	26
10	30	26	27	30	25	24	30	28	28	30	29	29	30	30	30

QN	Trials 6-15			Trials 16-25			Trials 26-35			Trials 26-45			Trials 46-55		
SP	1-3	4-6	7-9	1-3	4-6	7-9	1-3	4-6	7-9	1-3	4-6	7-9	1-3	4-6	7-9
M1	27	14	10	30	19	9	27	19	18	29	16	11	29	21	11
2	29	21	21	30	18	19	30	21	20	30	23	18	29	17	11
3	27	14	9	30	27	18	30	30	20	29	28	15	30	27	20
4	25	15	17	25	14	15	27	16	17	28	22	25	27	27	27
5	27	14	16	30	23	12	29	20	14	28	18	12	28	17	15
F1	27	21	17	30	25	18	27	22	23	30	29	29	24	21	24
2	25	16	7	30	4	3	26	10	7	30	11	7	27	11	7
3	30	24	19	29	18	19	30	26	19	29	22	23	30	25	18
4	27	10	9	27	17	9	24	18	18	29	25	20	30	22	17
5	27	14	15	30	25	12	29	16	13	30	23	17	28	22	10

Table 75

Anova - Noise x Serial position x Sex (Trial 1)

Source	SS	df	MS	F
Noise (N)	4.93	3	1.64	1.19
Sex (S)	0.93	1	0.93	<1
N x S	4.93	3	1.64	1.19
Subj. w gps.	71.80	52	1.38	
Serial position (SP)	28.01	2	14.00	21.54**
N x SP	9.80	6	1.63	2.51*
SP x S	1.87	2	0.93	1.43
N x SP x S	1.27	6	0.21	<1
SP x Subj. w gps.	68.20	104	0.65	

Table 76

Anova - Noise x Blocks x Sex (Number order 1-9)

Source	SS	df	MS	F
Noise (N)	56.69	3	18.90	< 1
Sex (S)	0.67	1	0.67	< 1
N x S	10.34	3	3.45	< 1
Subj. w gps.	1,039.08	52	19.98	
Blocks (B)	6.40	4	1.60	1.26
N x B	24.01	12	2.00	1.57^{+}
B x S	2.87	4	0.97	< 1
N x B x S	21.28	12	1.77	1.39
B x Subj. w gps.	264.32	208	1.27	

Table 77

Anova - Noise x Blocks x Sex x Serial position

Source	SS	df	MS	F
Noise (N)	1,531.90	3	510.63	3.25*
Sex (S)	63.56	1	63.56	<1
N x S	323.83	3	107.94	<1
Subj. w gps.	8,166.65	52	157.05	
Blocks (B)	268.13	4	67.03	5.32**
N x B	185.02	12	15.42	1.22
B x S	117.52	4	29.38	2.33^{+}
N x B x S	156.21	12	13.02	1.03
B x Subj. w gps.	2,618.74	208	12.59	
Serial position (SP)	10,187.22	2	5,093.61	141.29**
N x SP	981.89	6	163.65	4.54**
S x SP	10.87	2	5.43	<1
N x SP x S	137.73	6	22.95	<1
SP x Subj. w gps.	3,749.15	104	36.05	
B x SP	104.38	8	13.05	2.06*
N x B x SP	169.48	24	7.06	1.11
B x S x SP	38.69	8	4.84	<1
N x B x S x SP	174.49	24	7.27	1.15
B x SP x Subj. w gps.	2,639.03	416	6.34	