# STRUCTURAL AND FUNCTIONAL FACTORS AFFECTING SELECTIVE RESPONSE TO COMPLEX AUDITORY INPUT

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To my Father

FRANK S. TAYLOR

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Contents

## ABSTRACT

Models of attention and memory dating from the 1950s are reviewed with particular emphasis on dichotic listening experiments. Structural models, such as that of Broadbent (1958) are compared with, what are termed functional models eg. those of Neisser (1967), Shiffrin and Schneider (1977). Methodological and scoring problems in split span experiments are examined. Preliminary experiments were designed to show that the Gray and Wedderburn (1960) effect reflects a perceptual process which is largely unconscious rather than report preferences or strategies. The following four experiments investigated the effects of presentation rate, delayed recall and priming on responses to lists of differing semantic complexity. The faster presentation rate was found to encourage responses based on context rather than spatial location, as did delayed recall and priming of contextual lists by the contiguous presentation of similarly structured lists. Interference effects were found on lists with primes similar in content rather than structure. Evidence was found that context and category lists have different quantitative effects on responses. The interaction of variables in these experiments is emphasised and the results are interpreted in terms of functional models, with particular emphasis on components of analysis-by-synthesis (Neisser, 1967) levels of processing (Craik and Lockhart, 1972) and automatic processing (Shiffrin and Schneider, 1977).

# STRUCTURAL AND FUNCTIONAL FACTORS AFFECTING SELECTIVE RESPONSE TO COMPLEX AUDITORY INPUT

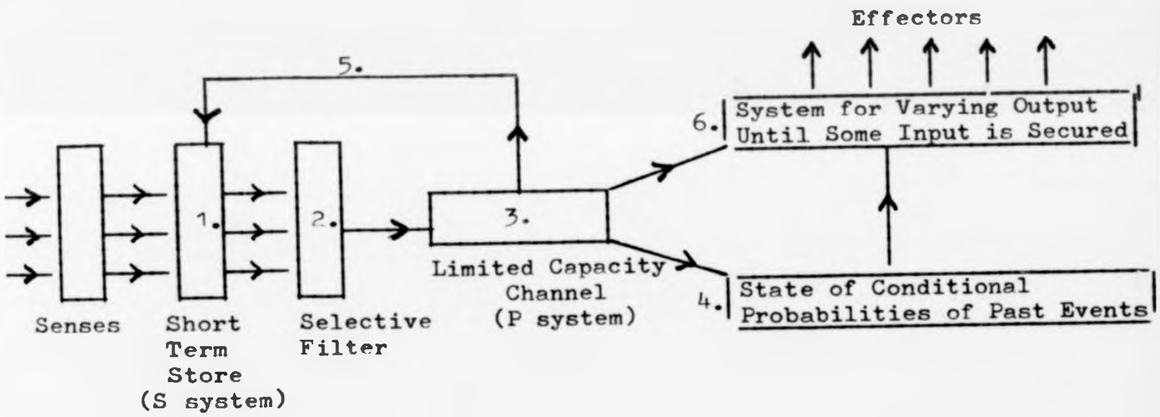
## Chapter 1. Literature Review

Early experiments concerned with attention to auditory stimuli, the division of attention, the focusing of attention and "breakdown" of attention have been so often cited that they hardly need repetition. However they retain so much importance both in a historical context and because they formed the basis of much of current theoretical thinking in the broad areas of attention and memory that any literature review would be incomplete without them. As will be seen, the experiments of the fifties and sixties are particularly relevant to the experiments which were carried out for this thesis.

Cherry's (1953) study is generally cited as the first which utilised the technique of "shadowing". Earlier experiments had generally used recall or identification methods to examine the problem of how man is capable of selectively attending to one stimulus and ignoring others (popularly called the 'cocktail party problem'). In Cherry's experiment subjects were asked to repeat a continuous message, as that message was presented to one ear, through headphones. This is the task referred to as shadowing and is a focused attention task. Cherry found that if two messages were presented dichotically, ie. one message to one ear and a simultaneous different message to the other ear, subjects could say very little about the message which was not shadowed. When a male voice changed to a tone or a female voice subjects did notice but they could not say, for instance, what language it was in, what individual words had appeared or what the semantic nature of the message was. The general finding that only rather gross physical characteristics in the unattended message could be identified, responded to or recognised was replicated by other authors such as Spieth, Curtis and Webster (1954) and Moray (1958). Although separation of two messages by presenting them through headphones to each ear has been most often used, some experiments used loudness, pitch or position in auditory space to confirm that physical parameters as opposed to content variables can be used to separate two messages arriving simultaneously when only one of them requires a response.

Partly on the basis of such results Broadbent (1958) proposed his influential filter theory, which provided the basis on which much later work has developed. Broadbent's original filter theory is outlined with reference to Figure 1.

Figure 1. Broadbent's Filter Theory. (from Broadbent, 1958)




1. Information enters the system and is held in a temporary store, or S. system. Experiments such as that of Broadbent (1954) showed that when three items were presented to one ear and three different items presented simultaneously to the other ear (the split span task) subjects typically reported the three items from one ear followed by the three from the other ear. It was therefore necessary to postulate a short-term store

which could hold the second set of digits until the first set had been processed.

2. A filter acts upon the incoming information. Broadbent (1958) originally identified intensity, pitch and spatial location as physical features able to act as a basis for selection by the filter.
3. The limited capacity channel carries the selected information while the rejected information is held in the short-term buffer store where it is subject to rapid decay. In a shadowing experiment this rejected message is the unattended message and does not get past the filter. In the split span experiment mentioned in (1) the second set of three digits is held in the short term store until the limited capacity channel has handled the first set when it, in turn, can gain access to the limited capacity channel, so long as there is not time for it to decay in the short term store. Broadbent (1957) had shown that when six items were presented to one ear and two items simultaneously to the other, recall of the two items was better when they were presented along with the last of the six items than with the first.
4. There is access to the long term memory store which allows analysis and recognition of the stimulus to take place.
5. Re-access to the buffer store means that the selected stimuli can be rehearsed if a response is not immediately required.
6. At the end of the limited capacity channel there is access to output motor mechanisms.

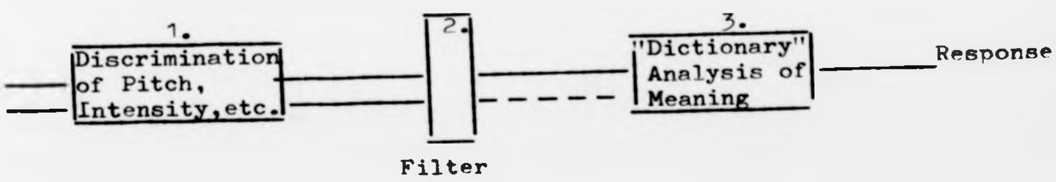
According to this theory breakthrough of an unattended message should not occur and one of the most important consequences of the publication of the model was that it opened the floodgates on attempts to show, experimentally, that breakthrough could occur, and later, that people can attend to two things at once with no loss of efficiency. It was very quickly discovered that an unattended message may intrude under certain circumstances. Moray (1959) showed that subjects involved in a shadowing task reacted if their own names were presented to the unattended ear. Other studies by Treisman (eg. 1960, 1964) also showed that the semantic content of the unattended message may cause intrusions. In one study (1960) she instructed her subjects to shadow a prose passage in one ear and to ignore the different message presented to the other ear. At a certain point during presentation the two messages changed ears. For instance the shadowed message and unattended message were as follows:

| | | | |
|---|---|---|---|
| Right ear Shadowed | : | leaving on her passage, an | |
| Left ear Unattended | : | singing men and then it was | |
| Right ear Shadowed | : | impression of grace and | ➔ is idiotic |
| Left ear Unattended | : | jumping in the tree | charm and .... |

In the above example the unattended message consisted of second order approximations to English. Fifteen of her eighteen subjects followed the prose passage onto the unattended ear for one or two words before reverting to the correct ear.

Interestingly, only three subjects reported that they had shadowed words on the wrong channel, the others being apparently unaware that they had done so. Such results clearly posed problems for Broadbent's filter theory and led to Treisman's (1960) formulation of a modified filter theory. Figure 2 shows the information flow as proposed in her theory.

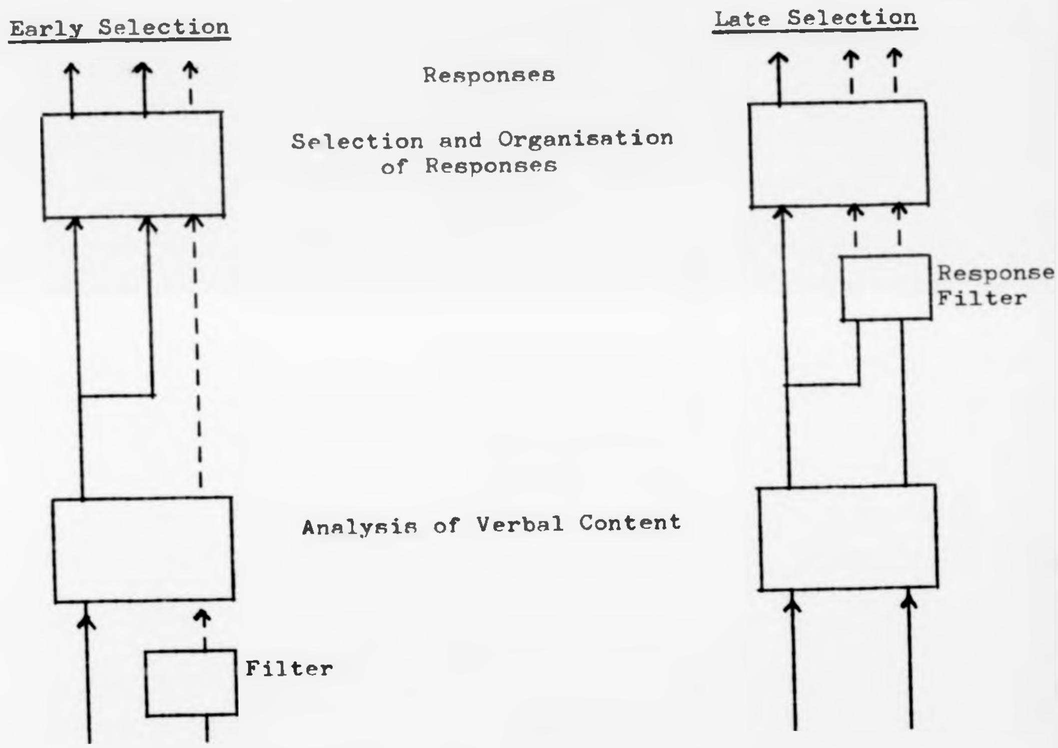
Figure 2. Treisman's Filter Attenuation Model. (from Treisman, 1960)



1. Parallel inputs reach a mechanism which analyses for crude physical characteristics. This information can be reported immediately regardless of what occurs in the next stages.
2. The messages reach a filter which, rather than blocking an unattended message as Broadbent proposed, merely attenuates it, so that it is considerably weaker than the attended message.
3. The firing of a dictionary unit represents the perception of the stimulus. Under normal circumstances the units which will fire will be those aroused by the stronger attended message, however some units, such as one corresponding to one's own name, or perhaps danger signals would have permanently lowered activation thresholds so that even an attenuated signal would cause the unit to fire. In order to explain her own results Treisman proposed that other units might have temporarily reduced activation thresholds on the basis of other incoming signals, so that when a message such as "the bells in the church" was received, the threshold for the unit corresponding to "rang" would be temporarily lowered so that an attenuated signal would fire it.

An alternative to Treisman's modified filter theory was proposed by Deutsch and Deutsch (1963). They contended that all inputs are analysed for meaning and that capacity is limited at the response end of the process. Analysis by a central structure, similar to the dictionary units proposed by Treisman gave a final degree of "importance" for each stimulus so that the one of greatest importance would be selected for response. There ensued a sometimes heated debate about the relative merits of the "perception" or "early selection" model of Treisman and the "response" or "late selection" model of Deutsch and Deutsch. (eg. Treisman and Geffen, (1967) Deutsch and Deutsch (1967), Treisman (1967), with both sides claiming experimental results as evidence for their theory. Both then, and now, it has been difficult to devise an empirical test of these theories since they differ fundamentally only in the level of processing at which selection occurs. This essential difference is represented in Figure 3.

Figure 3. Early and Late Selection Models. (from Treisman & Geffen, 1967)




Such a brief exposition barely does justice to the theories of Broadbent (1958) Treisman (1960) and Deutsch and Deutsch (1963). Experiments carried out in the 1950's and early 1960's have been extensively reviewed elsewhere, eg. Broadbent (1971), Kahneman (1973), Keele (1973), Moray (1969), Underwood (1976), and in book form, and give more detail than is possible here. This account so far serves only to outline one of the main controversys which was prevalent at that time.

Clearly one of the important distinctions between the models outlined concerns the effect of meaning on the processing of messages, and this is most clearly illustrated by the examples of shadowing tasks mentioned above. Equally important, particularly for Broadbent's original filter theory, were the split span tasks where, typically three items were presented to one ear and three different items presented simultaneously to the other ear, with subjects being asked to recall all six items. These experiments are concerned with divided rather than focused attention. Broadbent (1954, 1956, 1958) had shown (a) that subjects usually chose to report items from one ear before reporting those from the other ear, (b) that, when instructed to reproduce the items by pairs, subjects performed poorly, at fast rates of presentation (eg. at two items per second) as compared with ear by ear report and (c) that, at slow rates of presentation (eg. at one item per two seconds) subjects could report the items pair by pair as efficiently as ear by ear. These results were initially interpreted to mean that the filter in Broadbent's theory could not change its setting fast enough to allow alternation between ears at fast rates of presentation.

It quickly became apparent that this interpretation was wrong when Moray (1960) found that when three items were presented to one ear and three to the other in successive order, rather than simultaneously, ie. the items arrived in rapid alternation to the two ears, subjects were able to report them in the order of arrival just as well as in the ear by ear order. Other authors, such as Bryden (1962, 1964), Mackworth (1965) and Posner (1964) have investigated the effect of rate of presentation and such studies are further reviewed in Chapter 5.

In Broadbent's experiments and Moray's (1960) study the items presented were all digits and further problems arose when other experimenters started to employ different kinds of stimulus material.

In 1960, Gray and Wedderburn took issue with Broadbent's conclusions regarding the preference of subjects to use ear by ear recall and designed an important experiment to provide a cue for grouping other than spatial location. They presented dichotic lists in which digits and words alternated between ears

| | | | | | |
|---|---|---|---|---|---|
| eg. | Right Ear | : | Mice | 5 | cheese |
| | Left Ear | : | 3 | eat | 4 |

They found that subjects favoured report by meaning rather than by ear of arrival particularly when they had been informed that the words that they would hear would constitute a phrase. On the basis of this experiment Gray and Wedderburn suggested that ear of arrival was only one possible cue for grouping, most often used because digit lists provide no other cue.

Broadbent and Gregory (1964) carried out a series of experiments to investigate this effect. They instructed their subjects which order of report to use and found that it was no more difficult to report by meaning than by ear. However, they pointed out that the level of performance both in the Gray and Wedderburn study and in their own experiments, was very poor compared with in Broadbent's (1954) study.

They also examined the effect of presentation rate on this phenomenon by presenting monaural mixed letter and digit lists at four different rates. The lettersand digits were arranged either successively or alternating. Subjects who heard the items in successive order did best at the fastest rate while those who heard alternating letters and digits recalled more at the slowest rate. Broadbent and Gregory (1964) interpreted this as showing that classes of items could be selected just as physical channels but that extra time is needed to do so. These findings were compatible with Treisman's theory in that it provides a way in which a class of items or words which are highly probable in context might have their activation thresholds lowered in relation to other items.

Yntema and Trask (1963) carried out a similar experiment with similar results but interpreted these in a rather different way, more akin to the response theory of Deutsch and Deutsch. They proposed that as each item is heard it is 'tagged' with its characteristics. When six digits are presented the only tags which distinguish the items neatly are those of right ear and left ear. However, when three digits and three words are presented they are tagged, not only with the ear of arrival but with 'digit' and 'non-digit', so that it is as easy to recall by digit and non-digit as it is to do so by right ear and left ear.

It is clearly rather difficult to distinguish between the two models in terms of their predictive ability. Various experiments have been carried out in similar ways using words which are more or less associated, presented in lists of different lengths and at different rates of presentation. Most of these experiments have differed so widely in their approach to the problem that they are difficult to compare in any meaningful way with the result that the body of information on the 'Gray and Wedderburn effect' which does exist, is confusing and often contributes little towards our understanding of the processes underlying it. (See Chapter 2).

The experiments which are most closely related to those which will be reported here are those concerned with the effect of meaning on performance of the split span task. Apart from those already mentioned there are five others, carried out in the 1960s, which are worthy of special attention.

Bryden (1962, 1964) carried out a series of experiments in which he attempted to look more closely at the orders of report which subjects chose to use ie. he did not instruct his subjects as both Broadbent and Gregory (1964) and Yntema and Trask (1963) had done. In the first experiment (Bryden 1962) he presented different lengths of digit lists and identified three different orders of report which commonly occurred: pair by pair order, ear by ear order and what he termed 'attempted ear order'. An order in which the transposition of a single pair of digits would make an ear order were so classified eg. where the first and second words from the right ear was followed by the third word from the left ear followed by the first and second words from the left ear and the third word from the right ear. He found the classical result that subjects used pair by pair order more often as presentation rate decreased.

Bryden (1964) then used words which were associated in different ways. Four types of list which he used are illustrated in Table 1.

Table 1. Arrangements of associated words in Bryden's (1964) Experiment 2.

| R | L | R | L | R | L | R | L |
|---|---|---|---|---|---|---|---|
| bath | soap | Jack | dog | Jack | I | pick | red |
| rest | sleep | and | through | and | love | white | up |
| sun | moon | Jill | rest | Jill | you | sticks | blue |

In addition to these four types a control condition was presented in which the words were those presented in the pairs condition in a different order. Each type of list was presented at three different rates of presentation, 1 pair per ½ second, per second and per 2 seconds. Again, Bryden classified his results as pair by pair or ear by ear and he also identified a criss-cross order ie. for the criss-cross list in Table 1 a response of Pick up sticks, Red white blue. To avoid confusion between list and report this order of report will be referred to as 'switched' order. The results of his analysis indicated that ear by ear order was most commonly used in the triad and double triad conditions at all rates and that switched report was the most common response to criss-cross lists at all rates. However, the assocation between words in the pairs condition did not alter the classical finding that at fast rates ear by ear order was most common and that pair by pair report was found at slow rates.

These results suggest that switching from ear to ear at fast rates, as Gray and Wedderburn (1960) and Bryden found with their associated words presented in alternating consecutive order (criss-cross lists) does not occur in the same way with associated words presented simultaneously (Pairs lists). That is, consecutive switching is likely under favourable circumstances but simultaneous switching is not, at fast rates of presentation. This conclusion is, of course, based on the assumption that associations between words, as found in the pairs condition are equivalent to the phrases and associated words used in the other conditions in Table 1.

Other investigations have attempted to investigate simultaneous switching using phrases rather than associated words. Emmerich et al (1965) presented dichotic sentence lists at fast rates such as :

| | | | | |
|---|---|---|---|---|
| Right ear | : | He | not | his |
| Left ear | : | Will | change | mind. |

and 'scrambled' lists in which the words constituting the sentence were mixed up so that the words would not make a sentence either if ear by ear or pair by pair reports were used. The subjects were told which order of report to use, either ear by ear or pair by pair. Those subjects who were asked to use the pair by pair order of report were told that they would hear a sentence if they switched back and forth. Significantly more omissions were found on scrambled lists than sentence lists and more with ear by ear report than pair by pair report. It seems then that subjects can switch simultaneously at least when the stimulus material is contextual rather than associative. Unfortunately these results must be regarded as inconclusive since the only measure which Emmerich et al utilised was that of omissions and since it has been shown that there is an effect of telling the subjects what they might expect to hear, (eg. Miller, Heise and Lichten, 1951).

Yates, Martin and Dilollo (1970) carried out a similar experiment in which report by meaning would involve simultaneous switching. They presented three different list types at three different presentation rates. In one condition two four-word phrases were presented, one phrase to each ear, in another the phrases were presented in the simultaneous crossed fashion eg.

Right ear : There some she to
Left ear : Are left went town

and in the third condition the words were 'scrambled' as they had been in the Emmerich et al (1965) experiment. The subjects were not told to use any particular order of report and were not told that the words could constitute phrases. Yates et al (1970) found the usual result that ear by ear order predominates at fast rates and pair by pair at slow rates. The three list types differed in that the ear by ear lists were most often reported ear by ear and the pair by pair lists reported pair by pair while the scrambled lists showed almost equal tendencies. These results indicate much more conclusively that simultaneous switching is quite possible and this must throw some doubt on the equivalence of associated words and contextual material as used by Bryden (1964), and also on much of the material used in other experiments.

Yntema and Trask (1963) and, in an extended replication of that study, Bartz, Satz and Fennell (1967) used digits alternating with words which were not associated in any way. It is perhaps surprising that Yntema and Trask (1963) obtained results similar to those of Broadbent and Gregory (1964). In fact Bartz et al (1967) failed to replicate their findings. They did not find that report by category (digit and non-digit) was better than ear by ear report and furthermore, when subjects were left free to report in any order they liked, they most frequently used the ear by ear order on all list types including crossed lists. These results tend to suggest that associated words and words in context do not necessarily have equivalent effects on recall.

Broadbent (1971) agreed that the results of these experiments concerned with the effect of meaning cannot be reconciled with the original filter theory since they suggest that the filter based only on physical characteristics can be quickly alternated between one channel and other. He therefore appealed to Treisman's theory which allows for a contextually probable word to be processed in spite of the fact that it is not presented to the filter selected channel.

Broadbent (1971) therefore retained the concept of the filter but proposed that the selection of classes of item is carried out through a process called pigeon-holing. When subjects are told to listen to what is presented in one ear and ignore the other the filter mechanism attenuates the unwanted items. If subjects are told to listen for digits and ignore letters the pigeon-holing mechanism applies a bias to the wanted category so that they will be more easily triggered off than the unwanted category. This is, of course, similar to Treisman's theory where the threshold of certain dictionary units may be lowered through context. The setting of the filter which operates on physical characteristics can be changed quickly, but changing a pigeon-holing type of bias will take longer.

A rather different view was proposed by Neisser (1967). His model of analysis-by-synthesis suggested that perception is a reconstructive process. Early passive, parallel, pre-attentive processes analyse rather global and gross properties of an item or set of items, but apparently including the extraction of contextual ones (p213). In this latter aspect it differs from Broadbent's and Treisman's filter, although in other respects it is clearly similar. This preliminary system is supplemented by an active process of analysis by synthesis whereby the subject reconstructs what he is hearing and what he has just heard. The stimulus input is obviously a dominant determinant of this process but other factors are also important. As Neisser (1967) himself puts it:

> "Auditory synthesis ... can apparently produce units of various sizes. The listener can ask himself "What sounds were uttered?" or "What words were spoken?" or "What was meant?" and proceed to synthesize accordingly. In each case he must have a set of rules: phonetic, phonemic, syntactic, semantic, or what you will". (p194).

He further proposes that in addition to such rules the subject is able to use experience of what has gone before in the analysis, thereby allowing for the effects of context, familiarity, preference and expectation. In a shadowing experiment the unshadowed message is neither filtered out or attenuated. According to Neisser, it fails to enjoy the benefits of analysis - by-synthesis; it is not actively rejected but is not actively analysed beyond the early pre-attentive stage.

As mentioned before, the early and late selection theories proposed in the early sixties had much in common, in that they both envisaged a single channel system, within which parallel processing at one part of the system led on to a later stage of serial processing.These models are largely concerned with hypothetical structures, like the filter, as is shown in Figures 1 and 2. Although the transfer from parallel to serial processing was said to be either at the Perception end (Treisman) or Response end (Deutsch and Deutsch) it was not entirely clear that Deutsch and Deutsch (1963) intended their model to reflect a truly response or output selection process, as reported by Moray (1969). Nevertheless the two theories,and Broadbent's before it,were single channel theories where information is seen as flowing through the individual from input (stimulus) to output (response) and most of the efforts to examine the phenomenon lay in trying to find where the bottleneck or capacity limitation lay.

However, Moray (1967) proposed an alternative to a limited capacity, single-channel theory based on the kind of experimental results which had led to Treisman's reformulation of the filter theory, and on reaction time studies, such as those of Mowbray and Rhoades (1959) and Davis, Moray and Treisman (1961). These had shown that highly practised subjects showed no difference in reaction times when presented with two, four or eight choices. Moray and Jordan (1966) had also shown that practice abolished the presentation rate effect in the split span experiments whereby subjects could not accurately recall six digits pair by pair, as opposed to ear by ear. In this experiment subjects were trained to respond in parallel by using a keyboard so that they could type out the digits presented to the left ear with the left hand and to the right ear with the right hand. Not only did these practiced subjects show that they could alternate between ears at fast rates of presentation but subjects, responding vocally in the usual way, could do so after fifty practice trials. As Moray (1967) put it "Either (the limited capacity channel) has grown or the messages have shrunk". He therefore proposed a model of limited capacity, but where the overall capacity of the brain can be allocated to different functions, depending on moment to moment requirements of a task or tasks. This implied that, not only the information to be processed but also the processing itself took up capacity. Moray illustrated this concept with reference to the study of Moray and Taylor (1958) which had shown that subjects could not respond when speech shadowing low orders of approximation to English. This had also been found by this author (unpublished data) when subjects were asked to shadow long lists of random words at very fast rates of presentation. Although the subjects could hear the words and attempted to shadow them their attempts to do so often became more incoherent as the lists progressed. Moray's theory suggested that the input task in these situations was so difficult that the process of receiving and perceiving the message left no spare capacity for the response process to take place.

This review has so far been based largely on results from experiments using dichotic listening tasks of one kind or another. Many other experimental tasks directed at the examination of divided or focused attention contributed towards the theories so far outlined. Bimodal studies where one message was directed to one sense (the ear) and another message to another (the eye) were also carried out (eg. Broadbent and Gregory 1961, 1965). Recall and recognition tasks and tasks which required the identification of targets (eg. Treisman and Geffen 1967, 1968) were often employed and accuracy and latency most often used as response variables. Many of these kinds of experiments are explored in Broadbent's detailed review in 1971.

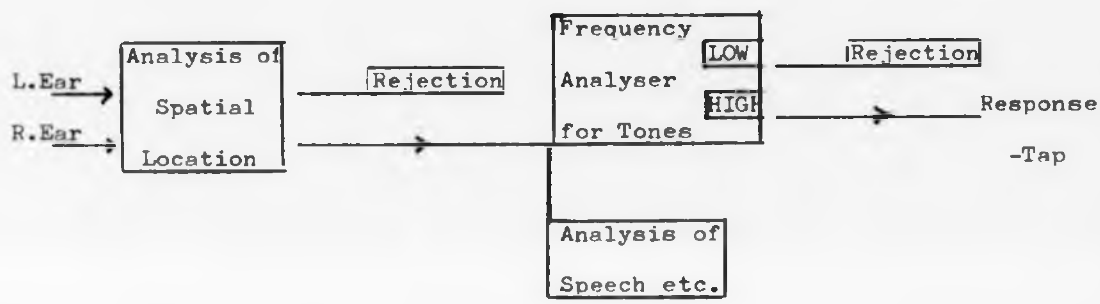
Thus at the end of the 1960's it can be said that single channel theories, either of the early selection or late selection variety held sway with Moray's theory providing a rather different view.

Treisman (1969) widened the scope of these kinds of models by suggesting that four different kinds of selection may play a role in attention. The first two: selection of inputs and selection of outputs correspond to Broadbent's filter theory and the Deutschs' late selection theories respectively but she also proposed what she called analyzer selection and target selection. The Stroop test may illustrate the operation of analyzer selection. In the Stroop test subjects are asked to look at a set of colour names which are themselves printed in different colours (eg. the word "brown" printed in green ink) and asked to identify the colour of the print. Measures in this kind of task indicate that the word itself causes interference in the naming of the colour. (Stroop 1935). This is another example where the semantic properties of a word interfere with selection of a physical attribute. In terms of the selection of analyzers (Treisman 1969) subjects find it difficult to select the analyzer for colour and reject an analyzer concerned with the semantic properties of the word.

In target selection, either a very broad target, such as human speech, may be specified or a narrow target, such as "John's voice saying goodbye". Input selection differs from target selection in that the former allows attention to the input to see what is happening in that particular channel, for instance, as in a shadowing experiment, while the latter specifies a particular end result of analysis, as in target identification tasks. Treisman illustrated (Figure 4) the different kinds of selection operating in a dichotic listening experiment where both shadowing and target identification of a high tone are required, (from Lawson 1966).

Figure 4. Operation of Input, Analyser, Target and Response Selection. (from Treisman, 1969)

TASK: "Tap when you hear a high tone embedded in speech on the right ear and ignore everything on the left"



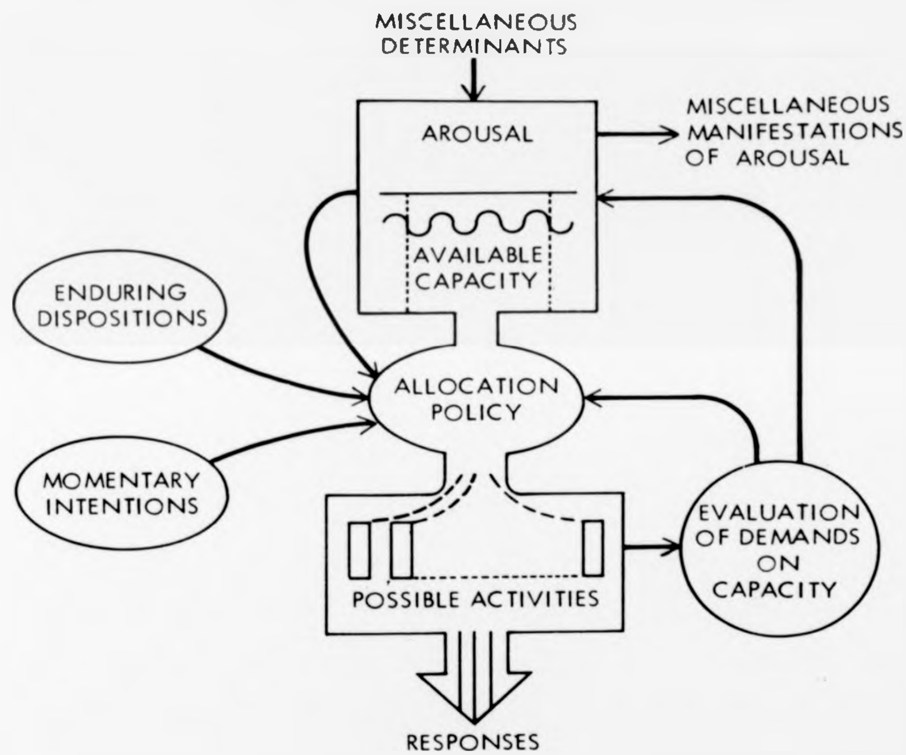

Broadbent (1971, 1982) made similar distinctions where filtering is equivalent to input selection, categorising corresponds to analyzer selection and pigeon-holing to target selection. Broadbent has emphasised that these operations take place after an unselective memory (the buffer store of filter theory) but are still not conceived of in terms of late selection. Treisman's (1969) proposals suggested that division of attention between analyzers was possible and thus that operations could proceed in parallel so long as the analyzers did not overlap.

Kahneman (1973) provided a rather different kind of theory which specifically addressed the role of effort and arousal in attention - what he called intensive aspects of attention. This theory is more closely allied to Moray's allocatable capacity model than the single-channel theories, but was not designed as an alternative to these theories. Rather, attention was viewed as an allocation of effort to some activity instead of another or others. This concept can be easily illustrated where effort apparently fails through various means eg. tranquilising drugs, or fatigue. Using an earlier example, that of Richardson who found that shadowing could not be sustained to long lists of random words, subjects certainly appeared to be expending effort over the task, they certainly reported their experiences as having been effortful; and certainly stressful, and the fact that their attempts at the task became less coherent the longer the task went on suggested that they were running out of energy. Time pressure is indeed one of the determinants of effort suggested by Kahneman. One of the most appealing things about this model is that it can apparently be measured by using physiological indices of arousal. Kahneman, Pearler and Omiska (1968) assessed both incentives and task difficulty in an experiment where subjects were rewarded or penalised for their performance on an easy or difficult task, arousal being measured by pupillary dilation. Incentives had little or no effect but task difficulty caused significant pupil diameter changes. Figure 5 illustrates Kahneman's model showing the relationships between different components of a capacity system.

Kahneman's model differs from the structural models of, for instance, Broadbent and Treisman, in implying that interference in selective attention is nonspecific and depends on the nature of the task which is to be carried out, rather than the limitations of specific mechanisms. However, Kahneman's view took into account both structural and what may be broadly referred to as functional aspects of attention.

Figure 5: Kahneman's capacity model for attention

(from Kahneman, 1973, page 10)



Kahneman's theory clearly attacked a rather different aspect of attention and has received support from, for instance Pribram and McGuiness (1975) who differed from Kahneman in differentiating activation from arousal, where Kahneman saw arousal, activation and effort as virtually synonymous. The theory has not received the same amount of experimental attention that other models have, though it has frequently been cited as a dimension of attention which requires further exploration and explanation.

Throughout the 1970's the field of study has widened to a great extent but late selection single channel models have probably been most extensively researched, with a body of evidence emerging showing that people can attend to two things at once <u>without interference</u> and other experiments continuing to concentrate on breakthrough of the unattended.

In the first category the study of Allport, Antonis and Reynolds (1972) is both well-known and fairly typical of this kind of experiment. As it was well established that subjects are unable to attend to two simultaneous auditory messages they utilised shadowing as a primary task with simultaneous presentation of words, either auditory or visually presented, or of pictures. When shadowing was accompanied by simultaneous presentation of recorded words and subjects were asked to perform a recognition task on the unattended stimuli, the usual result was found ie. that subjects could not recognise them at a better than chance level. Recognition of visually presented words was significantly better than this and recognition of pictures was significantly better than both. These results were used as evidence against a single channel theory since if shadowing takes up the full capacity of a limited capacity channel there should be no modality effects at all. Allport et al (1972) also reported an experiment where a shadowing task was combined with piano-playing from an unfamiliar score. They found that the subjects could sight-read the music while shadowing with only a few more errors than when attention was focused only on the piano playing. In the same kind of experiment Shaffer (1971) required shadowing and copy-typing with similar results. The typist made very few errors on either task but when required to shadow and audio-type she missed about 40% of the message. Errors increased still further to 60% when required to audio-type and read aloud the visually presented text. McLeod (1977) used, not shadowing, but a visuo-manual tracking task in combination with a simultaneous two-choice auditory reaction task and found that there was little interference when the response to the secondary task was vocal but increased when the required response was manual.

Experiments concerned with breakthrough of the unattended message also opened up new ground in the 1970's. Some representative examples are given here. Physiological effects have been measured using galvanic skin responses. Moray (1969) reported an experiment where a particular word, "country" was associated with electric shock. In a shadowing task GSRs were measured both when the word was presented on the shadowed and on the unattended ear. All subjects showed significant GSR responses when the word was presented to the attended ear and 25% did so when it was presented in the rejected message. Such a response, even in a minority of subjects suggests that the word had been processed to a semantic level. Corteen and Wood (1972) and von Wright, Anderson and Stenman (1975) have shown similar results. Corteen and Wood (1972) found that not only did their subjects respond to shock-associated City names, presented on the unattended channel, but also to other City names which had not been so conditioned. This generalisation effect suggests that subjects were not responding to the words on a phonemic level but on a semantic level. Von Wright et al (1975) found a similar result when synonyms of shock-associated words were used.

Experiments in both categories have been used to support the late selection single channel theoretical stance but it remains true that a filter attenuation model such as that proposed by Broadbent (1971) can accommodate much of these data.

A further development in the 1970's has been the proposal that a distinction may be made between conscious and unconscious processes. (Posner 1975, 1982). Even early experiments gave some indication that this might be the case. As mentioned already, in Treisman's (1960) study, subjects did report that they had not shadowed the unattended message when in fact they had done so when a prose passage switched from the attended to the unattended ear. Similarly, Bryden's (1964) subjects were unaware that they had reported by meaning rather than by ear. Neither of these experiments were specifically designed to address this question in any way and both authors reported the phenomena in a post hoc account of subjects introspections. Considerable evidence has accumulated that apparently unattended material may be processed to a semantic level without the conscious awareness of the subject. Posner (1978) reviewed evidence from dual task experiments which shed light on the matter more directly. It now seems clear that complex semantic processes can go on outside of attention. They clearly interact with attended processes by biasing certain thoughts or actions. Corteen and Wood's (1972) study suggests this as does a later experiment of Lewis (1970) who also utilised a shadowing task with shadowing latency the dependent variable. In the unattended message were synonyms, antonyms, words with a high sequential dependency or words unrelated to the simultaneous dichotic pair. Shadowing latencies were significantly higher when synonyms or words with a high sequential dependency were presented, though subjects were unable to recall the content of the unattended message.

In a Stroop test experiment Conrad (1974) also showed apparently unconscious effects of semantic properties of words. Subjects were asked to remember a sentence and then name the colour of ink of a single word. He showed that the latency of response was increased when the final word of the sentence was related to the Stroop word either in the sense in which it had been used or in a different sense, ie. latencies were longer to the word "marijuana" when the sentence was "we made tea in the pot". This suggests that both meanings of the word had somehow been "looked up". Priming tasks (Fischler and Goodman (1978)) have also shown that the semantic content of an "unattended" word may have a facilitatory effect on processing. Posner's (1975) cost-benefit analysis can be illustrated by priming experiments. If subjects are asked to make same-different judgements about a pair of stimuli reaction times are faster when the items have been preceded by a prime which is identical to one or both of the pair, whether or not the subjects can report the identity of the prime. In addition to the benefit of having a valid prime there may be costs, where reaction times are slower, when the prime is invalid. So Posner (1978, 1982) argues that any stimulus automatically activates certain processes which subsequently may enhance processing of the following stimuli which share those same pathways while there may be inhibition of stimuli which do not share the same pathways. Facilitation and inhibition effects also depend on the predictability of the prime. Reaction times seem to be slower with an invalid prime only when a valid prime has been expected, (Becker 1980). In Posner's formulation unconscious processing may be seen within a late selection model as the widespread activation of dictionary units or logogens (Morton 1969) with the late selection of responses being the conscious process.

A similar distinction to that of conscious and unconscious processing is that made by Schneider and Shiffrin (1977) and Shiffrin and Schneider (1977) of controlled and automatic processing. This theory, also a late selection model, is based on visual search experiments where four items are presented simultaneously following the presentation of a 'memory set' of items. The task requires subjects to detect any memory set items that appear in subsequent presentations, (the frameset). Three independent variables are manipulated (1) the number of items in the memory set and frame set vary from one to four (2) half the trials contain targets and half do not and (3) in a consistent mapping trial the memory set items never appear except as targets in the frame set (and vice versa). In a varied mapping trial memory set items may be non-targets in the frame set (and vice versa). In consistent mapping, memory set items are all from one category (eg digits) and non-targets in another category (eg. consonants). In varied mapping items were all from one category. The results show that varied mapping was affected by the number of items presented while consistent mapping was not, and varied mapping was always more difficult than consistent mapping (ie. visual search took longer). Shiffrin and Schneider (1977) proposed that a process of automatic detection, akin to Posner's unconscious process, operated in consistent mapping conditions and that controlled search was necessary in the varied mapping condition. Automatic processing is generally hidden from conscious attention and neither requires attention nor capacity. It develops in highly practised tasks while controlled processing is limited capacity processing which is often perceived by the subject. Where it is not perceived by the subject it is because the processing takes place so quickly. In applying their theory to the problems of divided and focused attention Shiffrin and Schneider (1977) suggest that divided attention is possible where the task is so well practised that automatic processing is carried out and that limitations in divided attention arise from the limited rate of serial operations in controlled processing. Interference from other stimuli on focused attention tasks occurs when the interfering items have initiated automatic processing.

Further evidence regarding conscious and automatic/unconscious processes has been reviewed by Underwood (1976) who brings together both memory and attention effects. It is clear that attention and memory cannot easily be kept separate and models of attention, such as that of Broadbent (1958) and others contain components of memory, often a short-term memory store and access to a long-term store. It is therefore useful to review some proposals regarding different memory systems, although it is scarcely possible to do justice to such a wide area of research in a review of this nature.

It would be untrue to say that there is general agreement about the number of systems in human memory, but a fairly resilient view is that a distinction can be made between short-term and long-term memory, or primary and secondary memory. (Waugh and Norman 1965). It is generally accepted, after the work of Miller (1956) that the span of short-term memory is "the magic number $7 \pm 2$". Although this may refer to seven separate items, such as digits, letters or words, it is clear that coding or chunking of items allows this memory to be considerably extended. (Pollock and Johnson 1965).

Baddeley and Patterson (1971) and Underwood (1976) amongst others have made the useful distinction between experimental procedures of short-term and long-term memory and of the operations performed by the subjects in such experiments. Because an experiment is designed as a short-term memory experiment, does not mean that the operations and processing which take place are solely concerned with one kind of memory and not another. Indeed, this seems implausible with regard to the short-term processing of the kind of semantic material used in the experiments which apparently show unconscious processing.

In addition to short-term memory and long-term memory, a third memory system, that of immediate or sensory memory is proposed. Neisser's (1967) echoic memory, Crowder and Morton's (1969) Precategorical Acoustic Storage and Massaro's (1970) preperceptual storage are all immediate or sensory memory systems. All of these operate so that an item is held very briefly in store and is best illustrated by the effect of a stimulus suffix. In a serial recall task, the final item or items are better recalled than earlier items. This recency effect can, however, be abolished by adding a further item, often a zero, although the subject knows that he will not be required to recall it. The suffix is therefore assumed to displace the final item from the brief echoic store. The estimates of the duration of immediate memory vary from Massaro's preperceptual store of a few hundred milliseconds to Crowder and Morton's estimate of less than two seconds.

Underwood (1976) makes three distinctions between immediate memory and short-term memory. First is the difference between the level of information stored. Items in immediate memory cannot be manipulated on the basis of semantic features while items in short-term memory may be remembered according to semantic features. Secondly, as noted above, information is lost from immediate memory in less than two seconds while the probability of recall from short-term memory is reduced over a period of 15-20 seconds (from Peterson and Peterson (1959)), or even up to forty seconds (Shiffrin 1973). The third difference is not undisputed and concerns whether or not entry into short-term memory is active or passive. Neisser's (1967) theory suggests an active process, while other theories have proposed that all inputs are analysed in a more passive way eg. that of Deutsch and Deutsch (1963) or Norman (1968).

Both acoustic and semantic coding have been found in short-term memory experiments using a variety of paradigms. The earlier argument that information is stored in short-term memory according to physical features and in long-term memory according to semantic features (eg. Norman 1968) has been shown to be untenable in its most dogmatic form, although it can be argued that results which show semantic coding in short-term memory are a consequence of items contacting long-term memory. eg Baddeley (1972).

It has also been argued that there is no necessity to distinguish between short and long-term memory. Kay (1968) gave a neat analogy of a unitary view of memory processes. If a coin is dropped into water and immediately removed, we can detect no alteration in it, apart from the fact that it is wet. Leave it in water for a year, however, and distinct chemical changes can be discerned. The same factor (water) is at work in both cases but measurement in the first case is too crude to detect any difference. In the same way, in memory if we commonly find items stored in terms of acoustic properties in short-term memory experiments and semantic properties in long-term memory experiments, it may be that there are not two separate stores but that memory is embellished through time in a way that is too complicated for our usual measurements.

Craik and Lockhart (1972) also took issue with the multistore approach in their influential paper dealing with levels of processing in memory. They presented the argument that the grounds for separating a short-term store from a long-term store were inadequate,being based on the findings that a short-term store has limited capacity, operates at a phonemic level and loses information within thirty seconds, as opposed to a long-term store having no known limit, operating at a semantic level and with slow or no information loss. The multi-store approach and models such as Broadbent's and those of Waugh and Norman (1965) and Murdock (1967) can be seen as structural models with information being passed from structure to structure while the view of Craik and Lockhart (1972) can be seen as presenting a functional model, similar to that of Neisser (1967), where the emphasis is placed on coding operations. The finding of sensory coding in immediate memory, phonemic coding in short-term memory and semantic coding in long-term memory led them to propose that the analysis of stimuli proceeds through a number of stages, from preliminary analysis of physical features to final stages of pattern recognition and meaning, often referred to as "depth or processing". Stimuli analysed to the semantic level will have a more persistent memory trace than those analysed,for instance, to the phonemic level. As opposed to the "box" structures of different memory stores. Craik and Lockhart regarded perceptual processing and memory as a continuum of analytic stages. Stimuli can then be retained at any one stage of processing by rehearsal (Type I processing) or can be processed further to a deeper level of analysis (Type II processing). The second kind of rehearsal would lead to better memory performance than the first. The depth of processing carried out will depend on whether the stimuli can be subjected to deeper analysis and also on what task the subject is required to perform.

> "Thus if the subject's task is merely to reproduce a few words seconds after hearing them, he need not hold them at a level deeper than phonemic analysis. If the words form a meaningful sentence, however, they are compatible with deeper learned structures and larger units may be dealt with".
>
> Craik and Lockhart (1972) p679.

Shiffrin (1976) has put forward a similar view, in which both immediate and short-term memory are embedded in long-term memory. In this system there are still two memory components, one active and temporary (the short-term store) and one permanent (the long-term store). Processing and encoding are concerned with simple physical attributes in early stages while later stages are concerned with elaborated features, such as semantic properties. It is worth quoting Shiffrin (1976) in his view of the relationship between selective attention and short-term memory (p215).

> "Selective attention is relegated entirely to the action of control processes in short-term store following the completion of the automatic stages of sensory processing ......... Sensory information is dumped into STS in parallel from all sensory sources, with almost no subject control applying before very high levels of processing are reached. Most of this information dumped into STS will be lost very quickly so that the subject must select certain important components for rehearsal, for coding and for decision making. This selective process within STS is assumed to be the locus of selective attention".

Shiffrin proposes various memory limitations. The active short-term memory will not automatically encode items which are not present in long-term memory. Information may be easily lost, more slowly for higher level information, and more quickly for purely sensory information.

This model shares many of the characteristics of Neisser's (1967) theory of analysis-by-synthesis, where a pre-attentive mechanism can control attention. The main difference would seem to be that the automatic process proposed by Shiffrin (1976) and in his later papers deals with all inputs where Neisser (1967) argued that irrelevant or unrequired inputs would not be processed in such great detail.

The relevance of Neisser's model and those of Craik and Lockhart (1972), Shiffrin (1976) and Shiffrin and Schneider (1977) to the present research lies in their view of short-term memory as a process rather than as a store, presenting functional models rather than structural models.

Wickelgren (1964) and Neisser (1967) have suggested that the active process in short-term memory is rehearsal, grouping or recoding and assert the equivalence of the three terms. Craik and Lockhart (1972) and Shiffrin (1976) however distinguish between two aspects of rehearsal: maintenance rehearsal, as in repeating or echoing the input either vocally or sub-vocally and coding rehearsal in which the item to be remembered is related "to other items in the list, to context, and to general knowledge in long-term memory". (Shiffrin 1976). He argued that maintenance rehearsal leads to storage of auditory and phonemic features which will not improve recall while coding rehearsal leads to storage of semantic and conceptual features which may improve recall.

This review started with the early single channel theories of Broadbent, Treisman and Deutsch and Deutsch. The theories of the 1950's and early 1960's have been considerably elaborated in the past twenty years, with new paradigms indicating how attention mechanisms postulated in those models may work. Reliable (and unreliable) effects of presentation rate, priming, masking, pre and post instruction and many other variables have been found on widely differing tasks and one must ask the question of how far we have travelled since Treisman and Geffen (1967) asked "Selective Attention: Perception or Response?". For many experimenters the answer is definitely "Response". The later theories outlined in this review concerned with conscious and unconscious processing, or automatic and controlled processing assume this viewpoint. On the other hand Broadbent (1982) defends the early selection model and accounts for many of the results showing interference from unattended messages within a framework similar to that of Treisman's attenuation model.

Both Sanders (1979) and Kinsbourne (1981) have regarded the main three models to be distinguished as single channel theory, allocatable-capacity theory (after Moray 1967) and multi-channel processing, similar to the proposals put forward by Treisman (1969) where limited capacity lies within separate mechanisms. Reference to one particular study may make the distinction between the three positions clear. It will be remembered that Allport, Antonis and Reynolds (1972) found that pianists could simultaneously shadow an auditory message and sight-read an unfamiliar piece of music. On the face of it this finding is difficult to reconcile with a single channel theory. As the authors point out the fact that a shadowing task takes up most or all of the limited capacity channel is central to a single channel theory. They argue for a number of independent processors, each having their own supply of limited capacity and where single channel theory would apply within rather than across mechanisms. Where the same processor is involved in two simultaneous tasks interference will occur but where the tasks are so dissimilar that there is no overlap between processors then there will be no interference. This model clearly explains why the subjects in the Allport experiment could apparently carry out two rather difficult tasks without interference. Broadbent (1982) however, has pointed out various problems in this, and other similar experiments. First there were signs of interference in the task. Timing errors in the sight-reading task were significantly higher in one session on the divided attention task than the piano-playing without shadowing. Memory for the content of the shadowed passage appears to have depended on the level of skill of the pianist at piano playing and ranged from 14% for the least proficient to 81% for the most proficient. Broadbent (1982) also pointed out that both prose and music are highly predictable and that music can be viewed ahead of the particular stimulus requiring response. The subjects in the experiment were also highly skilled at one task (sight-reading) and received practice of the shadowing task to a criterion level of errorless performance. One need only invoke the notion of automatic or unconscious processing to see how a single channel may handle these data.

An allocated-capacity model does not have too much difficulty in interpreting these data either since it accepts that parallel processing can occur with any task so long as the input and output can be kept separate. Again, with highly practised or skilled subjects one task may be carried out with a minimum of attention leaving spare capacity for the other task.

In conclusion, as far as the theoretical approaches are concerned the foregoing review scarcely does justice to the elaboration of the basic theoretical models which has occurred in the past twenty five years. Perhaps it is disappointing that no experimental technique has been devised to show that one or other is undoubtedly correct in spite of the flourishing of new paradigms, but the example given of the experiment of Allport et al (1972) makes it clear just how difficult it is to differentiate the theories. It seems likely that further advances will be made in attempts to elaborate the models still further in such a way that matters will fall into place through the build up of information from different sources, using different experimental paradigms rather than that a definitive experiment can be devised which will immediately allow all workers in the field to see the error (or otherwise) of their ways.

The very early experiments of Broadbent, Treisman and Moray were primarily concerned with divided and focused attention and showed how difficult, or sometimes impossible it is to divide attention. More recent experiments have attempted to show, and have shown, that it is perfectly possible to carry out two quite difficult tasks and apparently pay attention to both. It seems quite clear that the more similar two tasks are the more difficult it is to divide attention between them, and conversely that two tasks which are entirely dissimilar can be attended to without loss of information. The time for showing that one can talk and walk at the same time without stammering or tripping (much) would seem to be over. Progress in the field may come from various different directions; perhaps from the work of Posner or Kinsbourne on the psychobiology of attention. From a crude standpoint one may propose that a task controlled by one hemisphere will not interfere with a concurrent task controlled by the other hemisphere. Perhaps we now have enough neuropsychological knowledge to be able to map tasks as being more or less similar depending on their "functional cerebral distance" as proposed by Kinsbourne. He and his associates (eg. Kinsbourne and Hicks, 1978, White and Kinsbourne, 1980) have made some progress in this area. Other advances may be made in defining criteria governing automatic and controlled processes. We know that a controlled process may become automatic when highly practised but, since the theory is largely based on a single experimental paradigm we need to know how far the conclusions made on a visual search task apply experimentally to other kinds of attention research. Finally, recent experiments which show that the semantic content of words may have effects on attention and information processing of which the subject is not aware may provide further information, not only about the mechanisms of attention but also about the structure of semantic memory.

The experiments carried out here were designed for the last purpose and return to the early technique of the split span experiment with the primary goal of investigating the effect of semantic relatedness on divided attention. We know that such dichotic messages can be processed without loss of information. In even Broadbent's (1954) experiment some subjects can produce some lists of six digits without interference. In Gray and Wedderburn's (1960) study, again some of the time subjects can report "Mice Eat Cheese Three Five Four" perfectly although the different kinds of material used makes that more difficult. At its most basic level the following experiments continue the search for the source of interference in divided attention, but they do so through the medium of the concept of semantic relatedness.

In the following chapter some of the experiments from the 1960s are reviewed in greater detail from a methodological point of view and serve as a starting point for the experiments reported in chapters 4 to 7.

STRUCTURAL AND FUNCTIONAL FACTORS

AFFECTING SELECTIVE RESPONSE TO

COMPLEX AUDITORY INPUT

Chapter 2. Methodological Factors in Split Span Experiments.

One of the methodological problems which will be examined here has already received some attention. Moray and Barnett, (1965) conducted an experiment which investigated different methods of scoring errors after Moray (1960) found results which conflicted with those of Broadbent (1954). They analysed data from dichotic 6 digit lists at two presentation rates and with instructed report. They scored the lists in the way that Broadbent advocated ie. scoring only those lists which were completely correct, and they also scored omissions, commissions and order errors. They found that different error scores resulted in different sources of variance. Broadbent's method of scoring and the scoring of order errors gives the usual result - that ear by ear is more efficient than pair by pair report. Omissions however were affected by presentation rate but not strategy of report and commissions were affected by both rate and report, more commissions occurring at fast rates and when ear by ear report was used.

Moray and Barnett suggested that the different errors were tapping different parts of the processing mechanism so that, for instance, omissions, which are affected by presentation rate, occur at input while order errors occur at the retrieval stage. Since commission errors include various different kinds of responses,(eg. guessed, misheard, fusions) it is likely that some occur at input and others at retrieval.

Since Broadbent (1954) had scored only lists without an error of any kind it was suggested that he was drawing on all these types of error and perhaps mechanisms as was Moray (1960) when he used a score of mean errors. Such a state of affairs is likely to lead to confusion in the interpretation of results and unfortunately scoring difference is only one of the discrepancies in methodology which can be found in experiments which are supposedly investigating the same thing.

The related studies of Broadbent (1954), Moray (1960) and Treisman (1971) reveal just such discrepancies. Table 2 sets out variables, some of which have been shown to be related to performance of the task and others which seem likely to be of some importance. All three papers examined the effect of presentation rate on dichotic and binaural tasks. Broadbent's and Treisman's experiments were concerned also with list length: either six or eight digit lists.

The rates of presentation in the experiments not only differed but were reported in different ways. Broadbent reported his rates of presentation in terms of "interval between pairs", Moray reported "signals per ear per second". These have all been translated into milliseconds in Table 2.

Broadbent refered to the rates of 500 and 1,000ms as the fast rates, while Moray refered to fast medium and slow rates. Treisman's lists were presented at, what may be considered to be very fast rates, in comparison with most studies of presentation rate, but reported the stimuli, presented at one dichotic pair per 150ms as fast and at 250ms as slow. In all three experiments, presentation rate was a within subject factor, but Broadbent's subjects heard the lists at increasing rates, while Moray's conditions were counter-balanced so that half of the subjects experienced the fast condition followed by the medium and slow rates and the other half heard the lists in reverse order.

It should be emphasised that these experiments were not intended to replicate each other, and these comparisons mainly serve to show the disparity in methods and variables in experiments which are superficially investigating the same phenomena.

Table 2. Variables Reported in the Split Span Experiments of Broadbent (1954), Moray (1960) and Treisman (1971)

| Variables | Broadbent (1954) Experiment 2. | Moray (1960) Experiment 2 | Treisman (1971) |
|---|---|---|---|
| Stimulus Material | Digits | Digits | Computer-Generated Digits |
| Rates | 500ms.<br>1000ms.<br>1500ms.<br>2000ms. | 500ms.<br>1000ms.<br>2000ms. | 150ms.<br>250ms. |
| Inter-List Interval | ? | 10 secs. | ? |
| Trial Length per Subject | 20 | 120 | 168 |
| Practise | ? | 10 lists | ? |
| Response | Written | ? | Spoken |
| Number of Subjects | 24 | 16 | 7 |
| Scoring | Correct Lists | Mean Errors | Mean % Correct<br>Omissions<br>Order Errors |

In general there is a period of time between each list during which subjects make their response. It seems reasonable to suppose that the amount of time available has some effect on the responses. Longer intervals may allow the subject to rehearse, to change his mind and allows longer memory scan. In some experiments, eg. Yntema and Trask (1963) the tape recording is stopped after each list while the subject responds and is re-started by the experimenter. In most cases there is a fixed interval between lists. Of the three experiments examined here, Moray (1960) reports this inter-list interval, Treisman reports that it was variable and Broadbent does not report it, so we have no way of knowing whether the three methods were comparable.

The following two variables, the number of lists heard by each subject and the amount of practice given before the trial, are related. Studies have been carried out which have investigated the effect of practice. Moray and Jordan (1966) found that highly practised subjects could achieve over 80% correct using the pair by pair report order at fast rates of presentation - the condition usually found most difficult. Moray (1969) suggests that subjects' performance remains reasonably stable after the first few trials but there seems to be no real evidence to show that this is correct. Emmerich et al (1965) looked at the effect of practice, comparing omissions in the first and second halves of the experiment. They report "a highly significant improvement in performance from the first half of the experiment". Yates et al (1970) found that recall of material improved from 48% to 80% over twenty lists. Although the stimuli in both these experiments were not digits but words which formed sentences it seems wiser to assume that practise is important in all cases than to ignore it altogether. Neither Broadbent (1954) nor Treisman (1971) report whether or not their subjects were given pre-trial practice (it is likely that they did not) and probably even more serious is the fact that the number of lists heard by each subject in the different experiments are widely discrepant.

The type of response required in these experiments may also be a factor of importance. It could be argued that the conversion of the recalled stimuli to speech (Treisman 1971) may involve a different process and certainly takes a shorter time than that of a written response. (Broadbent 1954). Moray (1960) does not say which method his subjects used.

The number of lists heard by each subject, the number of subjects examined and the kind of design used are clearly related and of course the design used depends on the experimental aims (and sometimes on the number of subjects which can be obtained).

It is interesting to note that this is a discrepancy between the experiment of Yntema and Trask (1963) and that of Bartz et al (1967) which replicated and extended it. Subjects in the former performed the task under three different instruction conditions while those in the latter were divided into three different groups, each group performing under different instructions. It was on just this variable that the two sets of results differed. These two studies also differ in the inter-list interval, the number of lists which each subject heard and the amount of practise given.

Yates (1972) has also pointed out not only methodological problems but also technical ones. No-one who has ever attempted to construct a dichotic recording can be unaware of these technical difficulties but many of the experiments which have been published gloss over them. It is the exception rather than the rule for authors to make explicit how their stimulus tapes were constructed. Those who do describe their procedures tend to be those who have utilised sophisticated computer equipment.

The main difficulty in making dichotic tapes lies in synchronising the pairs of words on each channel. Yates (1972) points out that this has often been done by recording one channel in time to a metronome and then trying to record the second channel in synchrony by listening to the first channel through headphones. No doubt some tapes have been constructed with even less care. At the other end of the scale computer technology now allows us to generate recordings in which words are compressed so that they last exactly the same length of time and can be synchronised exactly (eg. Treisman, 1971). This of course allows one to be completely accurate as regards rate of presentation which is otherwise not the case.

Typically, presentation rates are reported as being so many items per second, one item per so many seconds or so many seconds between each pair but none of these terms convey precise information. For instance '2 items per second' may mean that there is half a second between the onset of one word and the onset of the next or between the end of one word and the onset of the next. Using the metronome method of recording it is impossible to be that specific. There is some doubt about whether or not exact synchrony of word pairs is strictly necessary. Yates (1972) thinks it is and has spent considerable time developing methods of generating accurate lists. (Yates et al 1970). Other investigators do not seem to afford it such importance. Yntema and Trask (1963) did use computer-generated lists but say "the recording was made automatically because the facilities happened to be available, not because such elaborate control of the stimuli is considered important in the present experiment". Morton et al (1976) believed that synchrony is important but suggest that pairs of items in dichotic lists should be synchronised, not by onset times but by their 'P-centres' - the psychological moments of occurence. Such P-centre synchrony results in, for instance, an onset asynchrony of 80 milliseconds for the digits seven and eight presented on different channels. Constructing dichotic tapes in such a way would be difficult and time-consuming, which is probably why there do not seem to have been any experiments carried out which have utilised this method.

There is, as yet, no general agreement about the importance of exact synchrony and therefore the question must be left unanswered.

Moving on to those experiments which used more meaningful material than digits, we again find many discrepancies in methodology. Experiments which are particularly relevant to this thesis are those of Gray and Wedderburn (1960), Broadbent and Gregory (1964), Yntema and Trask (1963), Bartz et al (1967), Yates et al (1970) and Bryden (1964). All these were concerned with lists which were structured in some way.

These six experiments have little in common as far as stimulus material is concerned although superficially they appear to be examining the same phenomenon. All are based on the Gray and Wedderburn (1960) experiment and used dichotic lists of associated items. Table 3 gives examples of the kinds of lists used.

Gray and Wedderburn presented lists in which phrases were alternated with digits, called Crossed Context/Digit Lists in Table 3. Broadbent and Gregory used Crossed Digit/Letter Lists (although these were presented monaurally in alternating order, rather than dichotically). Bryden employed lists in which context was alternated with category and also lists in which associations between words were between simultaneous pairs rather than consecutive words. Yates et al also presented lists with simultaneous crossings but these were context lists.

Table 3. Dichotic Stimulus Material used by (1) Bartz et al (1967), (2) Broadbent and Gregory (1964), (3) Bryden (1964), (4) Gray and Wedderburn (1960), (5) Yates et al (1970) and (6)Yntema and Trask (1963).

Digit Lists

| | | | |
|---|---|---|---|
| 3 | 6 | 8 | (2) |
| 2 | 9 | 7 | |

Word Lists

| | | | |
|---|---|---|---|
| Mice | Run | Swing | (1) (3) |
| Chair | Glass | Please | (6) |

Straight Context Lists

| | | | |
|---|---|---|---|
| Far | From | Home | (1) (3) |
| Sit | Down | Here | (6) |

Digit/Word Lists

| | | | |
|---|---|---|---|
| One | Three | Eight | (1) |
| Bet | Coil | Good | (6) |

Context/Word Lists

| | | | |
|---|---|---|---|
| Big | And | Strong | (3) |
| Bet | Coil | Good | |

4 Word Context Lists

| | | | | |
|---|---|---|---|---|
| She | Went | To | Town | (5) |
| There | Are | Some | Left | |

Disordered Context

| | | | | |
|---|---|---|---|---|
| Are | Town | She | To | (5) |
| Went | Some | There | Left | |

Crossed Context/Digit Lists

| | | | |
|---|---|---|---|
| Mice | Nine | Cheese | (4) |
| Two | Eat | Seven | |

Crossed Digit/Letter Lists

| | | | |
|---|---|---|---|
| 3 | B | 8 | (2) |
| A | 6 | G | |

Crossed Context Lists

| | | | |
|---|---|---|---|
| Far | Down | Home | (3) |
| Sit | From | Here | |

Crossed Digit/Word Lists

| | | | |
|---|---|---|---|
| One | Coil | Eight | (1) |
| Bet | Four | Good | (6) |

Crossed Context/Category Lists

| | | | |
|---|---|---|---|
| Red | And | Blue | (3) |
| Big | White | Strong | |

Pairs Lists

| | | | |
|---|---|---|---|
| Bath | Sun | Toe | (3) |
| Soap | Moon | Foot | |

Crossed Context by Pairs

| | | | | |
|---|---|---|---|---|
| She | To | There | Some | (5) |
| Went | Town | Are | Left | |

Methods of scoring in these experiments also differed, to a certain extent but not entirely depending on whether report was free or instructed. Only the experiments of Yntema and Trask and Bartz et al were consistent both in terms of stimulus items and scoring but, as mentioned earlier, there were other differences in methodology which may have contributed towards the differing results.

The many inconsistencies between experiments and the number of different variables which may affect recall of contextual or associated lists make it clear that there are many questions still to be answered about the Gray and Wedderburn effect. These can bear more systematic investigation and it was with this view that the first experiments in this thesis were designed.

# STRUCTURAL AND FUNCTIONAL FACTORS AFFECTING SELECTIVE RESPONSE TO COMPLEX AUDITORY INPUT

## Chapter 3. General Methodology

1. Subjects : Subjects in all experiments were 1st and 2nd year psychology undergraduates who participated in the experiments as part of their course requirements. Only subjects who fulfilled the following conditions were tested : that they were native English speakers, that they had no hearing difficulties to their knowledge and that they had no previous experience of dichotic listening tasks.

2. Stimulus Material : Different kinds of list were presented in different experiments but all focused primarily on Crossed Context lists (similar to the criss-cross lists of Bryden 1964). In these lists two phrases or other associated items are presented dichotically, the middle words of each phrase being 'crossed' eg.

| | | | |
|---|---|---|---|
| Right ear | Mice | Black | Cheese |
| Left ear | Big | Eat | Dog |

In formulating lists an effort was made to ensure that similar sounding words did not coincide and that the words could not be re-arranged to make a meaningful phrase other than that which was intended. All words, digits and letters used in the experiments were monosyllabic and most could be found in the Thorndike and Lorge (1944) list of AA frequency words. Those which were not high frequency words were contained in highly associated phrases such as "Pigs Don't Fly" or "Rum and Coke" or in category lists, where some category names are not contained in the high frequency list.

3. Recording : All tape recordings were made in the same way. The lists were read by a female speaker seated in a sound-attenuated chamber with remote control of a Revox A77 half-track stereo tape-recorder situated outside the booth. The rate of speech was paced by a battery operated metronome with an ear-phone attachment. The words to be presented to one ear were recorded on one channel of a tape and the words for the other ear on one channel of a separate tape. Each list was preceded by the word 'ready' recorded on

both channels, there being a three second interval between the onset of 'ready' and the onset of the first word in the list. The words were read in a clipped fashion calculated to maintain each word as a distinct item and to ensure that the words did not slur into one another.

The words on the two channels were combined by re-recording one onto the empty channel of the other through an auxiliary input. Prior to this the first channel itself was re-recorded onto a new tape through an auxiliary input so that the signal to noise ratio on the two channels would not differ.

The pairs of words in each list were synchronised by moving both tapes by hand, with the reel motors off, to the start of the word 'ready'. Because of the distance between the playback and record heads of the two tape recorders the channel which was recording was shifted back that distance from the start of the word 'ready' while the to be recorded tape was set just fractionally before that word. Both tape-recorders were Revox A77 makes. The record switch one and playback switch on the other were started simultaneously.

Given perfect timing in the original lists and perfect synchrony of the first words it should be possible to achieve synchrony of all the pairs of words in all the lists without stopping but in practice the tapes had to be stopped after no more than four or five lists (and usually more frequently) and the procedure repeated. Synchrony was checked by running the finished recording through a Honeywell 2206 visicorder. Any lists from which pairs of words showed an onset difference of more than 60 milliseconds were re-synchronised and where necessary were re-recorded.

4. Instructions to Subjects : All lists were presented through stereo headphones. The task requirements differed from experiment to experiment but, in most, subjects were told that they would hear three words in one ear and three words simultaneously in the other. They were informed if stimuli other than monosyllabic words ie. letters, were used. Subjects were never told that the words might make a meaningful phrase or were associated in any way.

At the start of every experiment one list was presented, the correct response to which was given and all subjects were asked if they understood the requirements of the task. Correct responses were those where the item appeared on the response sheet in the position to which it had been presented and under the correct heading of Right and Left Ear. In no experiment were subjects given any practice lists. They were told how long they would get between lists to make their responses. In all experiments the subjects were required to write their responses on prepared response sheets. In general they were asked to write down under 'L' the words that they had heard in their left ear and under 'R' the words that they had heard in their right ear in the order in which they had heard them. They were never instructed to use any particular report strategy but only to indicate what they had heard. All instructions were read to subjects by the experimenter who remained in the room during testing.

5. Rate : In all the experiments except where rate was an independent variable, the words were recorded and presented at a rate of 1 word per 500 milliseconds ie. there was 500 milliseconds between the onset of one word and the onset of the next. The interval between the end of one word and the onset of the next varied but was never less than 30 milliseconds and never more than 100 milliseconds as measured on the Honeywell visicorder.

The rate of 1 word per 500 milliseconds was used for various reasons. It has been the rate most often used in dichotic experiments, often used as an example of a fast rate. Secondly, when recording the lists it was found that it was difficult to speak the words without any intonation and to maintain the words as separate items at rates much faster than this. At faster rates the words tend to slur into each other without any pause between them unless they are spoken in a very clipped manner which reduces their intelligibility.

STRUCTURAL AND FUNCTIONAL FACTORS
AFFECTING SELECTIVE RESPONSE TO
COMPLEX AUDITORY INPUT

Chapter 4. Preliminary Experiments 1 - 4

The first four experiments carried out were of a largely exploratory nature, initially designed to investigate the possibility that switching from ear to ear, as first found by Gray and Wedderburn (1960) is more than the report phenomenon which experiments, particularly in the sixties, showed it to be. It was reported by Bryden (1964) that subjects believed that they were using an ear by ear report when in fact they had recalled the items in some other order. When the list

| | | | |
|---|---|---|---|
| Right Ear | Big | White | Strong |
| Left Ear | Red | And | Blue |

was presented, subjects might recall the items in the order "Big And Strong Red White Blue", but say that they had reported all the items from one ear and then all the items from the other. This observation is similar to that made by Treisman (1960) who found that subjects shadowed a prose passage onto the unattended ear when the context of the shadowed message was continued there, but said that they had only shadowed words from the one ear. In both cases it appears that the physical cue of spatial location was overridden by the semantic cue and that subjects were unaware of it.

In split-span experiments the words "order of report" and "order of recall" have often been used interchangeably to describe what is generally serial output. The experiment of Moray and Jordan (1966) differs in this respect in that they trained subjects to respond in parallel on a keyboard. However, subjects have usually been presented with simultaneous inputs and asked to report them in a serial way, either verbally or by writing them down in a list. Their memory of the input is, however, that of three items presented to one ear and three to the other. In the example given above, order of report : Big And Strong Red White Blue can be distinguished from the order of recall which appears to have been

| | | |
|---|---|---|
| Big | And | Strong |
| Red | White | Blue |

The order of report is often examined in terms of preferred strategy or most efficient strategy but it has not been explicitly suggested that subjects thought that they had actually heard Big/Red And/White Strong/Blue rather than the Big/Red White/And Strong/Blue which was presented.

The first four experiments were concerned with the investigation of this distinction.

Experiment 1

Method  Eight subjects were tested. The stimuli consisted of 24 straight context and 24 crossed context lists, examples of which are given below in Table 4.

Table 4. Examples of straight context and crossed context lists.

| Straight Context | | Crossed Context | |
|---|---|---|---|
| R. Ear | L. Ear | R. Ear | L. Ear |
| Far | King | Mice | Big |
| From | And | Black | Eat |
| Home | Queen | Cheese | Dog |

Straight context lists consisted of two phrases, each of which were presented dichotically to each ear. Crossed context lists consisted of two similar phrases in which the second words were presented to the opposite ear.

The order of presentation of the 48 lists was randomised and was the same for every subject. There was a pause of twelve seconds between each list to enable the subjects to make their responses.

Instructions: Subjects were instructed in the standard manner. (See Chapter 3). In addition they were asked to indicate whether or not they were certain or uncertain that what they had written was correct by marking the word certain or uncertain which appeared on the response sheet at the end of each list.

Results

Six different types of error were identified as follows:

1. Omissions : Any word which was presented but was not accurately reported was an omission. Omissions were therefore recorded when a word appeared to have been misheard or guessed, but not if it was positioned incorrectly.

2. Between Ear Errors : (Switched responses). This type of error was recorded when a word was accurately recalled in the correct position but identified as having been presented to the wrong ear.

| | | | | | |
|---|---|---|---|---|---|
| eg. | a presentation of | Mice<br>Big | Black<br>Eat | Cheese<br>Dog | and |
| | a report of | Mice<br>Big | Eat<br>Black | Cheese<br>Dog | results in the |

two second position words being scored as switched responses.

3. Within Ear Errors : These were recorded when words were recalled in the wrong position but identified as having been presented to the correct ear.

| | | | | | |
|---|---|---|---|---|---|
| eg. | a report of | Mice<br>Eat | Cheese<br>Big | Black<br>Dog | ,using the previous example, |

results in the second and third position words from one ear and the first and second position words from the other ear being scored as within ear errors.

4. Ear and Position Errors : These were recorded when a presented word appeared in the wrong position and was identified as having been presented to the wrong ear.

5. Commission Errors : There were usually words which were reported which had not in fact been presented. They were of four different types (a) misheard words eg. back or bat instead of black. (b) guessed words, eg. white instead

of black. (c) miscellaneous words. This type of commission error included words which had no apparent phonetic or semantic connection with the words which had been presented. Other words which might have been combinations of misheard, guessed or fusion errors were also included in this category. The final kind of commission error were designated repeat errors. These were words which had been presented which were reported twice: almost invariably once in the correct position and correct ear and once in the correct position and wrong ear

| | | | |
|---|---|---|---|
| eg. | Mice | Eat | Cheese |
| | Big | Eat | Dog |

Only responses which accurately reflected the order and ear to which a word was presented were recorded as correct responses.

Table 5 gives the mean percentage of responses of different types.

1. Omissions These errors were subjected to analysis of variance (List x Position x Subject). The results indicated a significant difference between lists, $F(1,7) = 46.14$, between positions, $F(2,14) = 26.84$ and that there was a significant List x Position interaction $F(2,14) = 24.56$ (All significant at the .01 level). The ANOVA summary table is given in Appendix 1.1.

   The Scheffe (1953) test (Edwards, 1968) was carried out to compare treatment sums. Within the straight context lists no significant difference was found between the positions; within the crossed context lists all three positions differed from each other. Comparison of the two types showed that crossed context lists produced significantly more omissions than straight context lists on the first and second positions but no difference was found for position 3. These differences are illustrated in Table 6.

Table 5. Mean percentage of words presented in each position from straight context and crossed context lists which were recalled in different positions or omitted

| Lists | Straight Context | | | Crossed Context | | |
|---|---|---|---|---|---|---|
| Positions | 1 | 2 | 3 | 1 | 2 | 3 |
| Omissions | 12.76 | 12.24 | 10.93 | 27.09 | 36.2 | 15.11 |
| Correct | 86.46 | 86.46 | 89.06 | 71.09 | 24.74 | 81.51 |
| Switched | 0.26 | 0.26 | 0. | 0.78 | 38.02 | 2.08 |
| Within Ear Error | 0.26 | 0.78 | 0. | 1.04 | 0.26 | 1.04 |
| Error Within & Between Ears | 0.26 | 0.26 | 0. | 0. | 0.78 | 0.26 |
| Commissions | | | | | | |
| Misheard | 1.82 | 0. | 2.34 | 4.95 | 4.17 | 4.95 |
| Guessed | 2.34 | 0.52 | 0.26 | 1.56 | 2.86 | 0.52 |
| Miscellaneous | 0.52 | 1.04 | 1.04 | 0.78 | 3.65 | 0.52 |
| Repeats | 0.52 | 0.52 | 0. | 0.52 | 5.47 | 0.26 |
| Total Commissions | 5.2 | 2.08 | 3.64 | 7.81 | 16.15 | 6.25 |

Table 6 : Individual comparisons of each word position between and within straight and crossed context lists.

| | | STRAIGHT CONTEXT 1 | STRAIGHT CONTEXT 2 | STRAIGHT CONTEXT 3 | CROSSED CONTEXT 1 | CROSSED CONTEXT 2 | CROSSED CONTEXT 3 |
|---|---|---|---|---|---|---|---|
| STRAIGHT CONTEXT | 1. | | NS | NS | * | | |
| | 2. | | | NS | | * | |
| | 3. | | | | | | NS |
| CROSSED CONTEXT | 1. | | | | | * | * |
| | 2. | | | | | | * |
| | 3. | | | | | | |

NS = No significant difference

* = Significant at, at least, .05 level

2. Between Ear Errors (Switched Responses)

It is clear from Table 5 that only second position words from crossed context lists showed switched responses to any significant extent and these were the most common responses to second position words of that kind of list.

3. Within Ear Errors and 4. Ear and Position Errors

Rows four and five of Table 5 give these scores. These errors occurred only rarely and generally appeared in lists from which there were also omissions.

5. Commission Errors

These errors are difficult to examine because they are varied. There seems to be no valid reason for subjecting them to analysis across all categories of commission since it is unlikely that they occur for the same reason. Reference to Table 5 indicates that crossed context lists produce more misheard commissions than do straight context lists and that this is true of all three positions equally. Guessed commission errors do not appear to be much more frequent on crossed context lists but miscellaneous commission errors, those which appear to bear little relation to any words presented seem to occur more often on second position crossed context lists.

The repeat commissions also appeared rarely but it is worth noting the comparatively high percentage which occurred on second position words of the crossed context lists. These generally appeared on lists with few or no omissions and meant that one phrase was correctly recalled and the other phrase was recalled with the second word switched. These repeat commissions were not, however, classified as switched responses.

The above method of classifying errors allows a fuller picture of the responses made than other methods, previously described in Chapter 2, dealing, as it does, with each individual item. Broadbent (eg. 1954) has used a scoring method which would discard almost all the above data. Since we are primarily interested in switched responses to crossed context lists there is little point in examining only those lists from which all words were correctly recalled and in the correct position. However, it is useful to examine the lists from which all six words were correctly recalled regardless of their position. Table 7 gives the mean percentage of these lists which were positioned correctly ie. as presented and those which showed the switched response. The very small number of these lists which were positioned in a different way were lists in which either the first or third position words were recalled in the switched position.

Table 7 : Mean percentage of lists from which all six words had been recalled (a) in the correct position, (b) with the second position words switched and (c) in some other positions.

| Lists | Correct | Switched | Other | Total |
|---|---|---|---|---|
| Straight Context | 66.15 | 0 | 0 | 66.15 |
| Crossed Context | 5.21 | 22.92 | 1.04 | 29.17 |

As expected, this method of scoring results in 70% of the data from the crossed context lists being discarded, but only 34% from the straight context lists.

These figures fairly accurately reflect the omission rates shown in Table 5 where total omissions equalled 36% on straight context and 78% on crossed context lists. The ratio of correct to switched responses is much greater using this method of scoring, than the item by item method, a point which is returned to below.

Finally, these data may be examined using the same kind of system as that used by Bryden (1964) and by Yates et al (1970) in which each half-set is analysed. Bryden classified different orders of report as temporal (pair by pair), ear order (correct) or criss-cross (switched). There is no equivalent here of the temporal order but it is possible to use a similar system as far as correct and switched orders are concerned. For each half-set, ie. three words reported from one ear, he gave a score of 1.

The present data were classified according to the words appearing under the headings Right and Left, three words having to be reported before a score was given. Table 8 gives these results. The mean scores have been transformed in order to compare these results with Bryden's by dividing the true mean scores by six since Bryden's data were based on only four lists as opposed to the 24 used in the current experiment.

Table 8 : Mean frequency of correct and switched recall sequences for each half-set. Bryden's (1964) equivalent scores are shown in brackets.

| Lists | Correct | Switched |
|---|---|---|
| Straight Context | 6.38 (6.59) | 0.04 (0.03) |
| Crossed Context | 1.5 (1.28) | 3.1 (2.06) |

Bryden also gave percentages of correctly recalled words and thus his omission rate can be calculated as 5.5% on straight context lists and 25.7% on crossed context lists. The equivalent scores in this experiment are 12.24% and 32.03% respectively.

Discussion

As far as the primary aim of the experiment is concerned ie. to indicate that there is reason to suspect that switching is a perception or recall phenomenon rather than a report phenomenon, the results are straightforward. 38% of the words in the second position on crossed context lists were recalled in the switched position rather than the correct position (24%). Since the recording sheets mirrored the input format to show what the subjects had heard, it seems that they thought that they had actually heard a straight context pair, not just that it was easier to report by context than by spatial location. It appears then, that this was an unconscious decision.

Whichever method of classifying the data is used, switching the second words on the crossed context lists so that the lists are recalled by meaning rather than by ear is found to be the most common response to that kind of list. Since Bryden's results are the only ones which are based on material similar to that used in the present experiment they are the only ones with which they can be meaningfully compared. Even so his method differed in that he presented his subjects with a smaller number of lists. His lists also differed from the present ones in that, in his crossed context lists, only one sequence constituted a phrase, ie. a single phrase crossed with three other unassociated words. His sequences also differed in that two were not phrases but highly associated words (eg. red, white, blue and one, two, three).

Bearing these differences in mind the results of the analysis are reasonably similar. In examining the frequency of switched and correct recall sequences in Bryden's and the current data (Table 8) only switched recall of crossed context lists shows as much as a one point difference. This could be explained by the fact that he used one phrase and three unassociated words rather than two phrases. Bryden's lists show fewer omissions on both straight and crossed context lists and it seems likely that this reflects the fact that only four lists of each type were used in his experiment as opposed to twenty-four in the present experiment. His phrases therefore used more highly associated words than was possible in constructing twenty-four lists.

Broadbent's classic method of scoring, whereby only lists from which all six words have been recalled are scored, results in an even higher proportion of switching to correct lists. It is interesting to note that the more information required by the scoring system in order to achieve a score of correct or switched, the greater is the ratio of switched to correct responses. For instance the item analysis originally carried out in this experiment may give a correct or switched score even if the middle word is the only one of the list which was reported with the other five words omitted. Using this method a ratio of 1 correct to 1.54 switched responses was found. Using Bryden's method, modified here, the first and third words from one side and the second from either side must be reported in order to achieve a score. In this case the ratio rises to 1 correct to 2.07 switched responses. Finally, using the Broadbent method of scoring where all six words must be reported the ratio is 1 correct to 3.67 switched responses. These results suggest that subjects are more likely to recall the middle words in the switched position when they have accurately perceived the first and third words and that the cue for meaning is more than twice as likely to be followed when all six words have been perceived than when first or third words are omitted. An alternative conclusion is that when the semantic cue is followed, recall of total lists is more efficient.

Moray and Barnett (1965) suggested that different kinds of error reflect different parts of the information processing mechanism. They found that omission errors were affected by rate of presentation but not by retrieval strategy and concluded that most omissions occur at input. They pointed out themselves that this is more likely to be true when a limited set of digits is presented than when less homogeneous material, such as that used in this experiment, was used. Where six digit lists are concerned one would not expect much forgetting to occur but it may be more likely when two phrases are presented.

In the present experiment it is clear that the crossed context affects recall of the words presanted in that the omission rate on first words in the crossed context lists is significantly higher than on the straight context lists. Where such retroactive interference takes place a later stage of processing seems to be implicated and points out the error of a view of items flowing through the system from input to output without any return or "check-back". These points are followed up in later discussions but it is worth bearing in mind that it is not only the perception or recall of the middle words which is affected by the crossed context, but also the preceding and perhaps the final word.

The data given in Table 5 shows a very small percentage of within ear errors with no effect of crossed context. Commission errors, particularly those which appear to have been misheard, were more frequent in the crossed context lists and repeated word commissions were particularly evident on the middle words of crossed context lists. These latter errors were interesting in that they indicate a further solution to the dilemma of following the physical cue of ear of arrival or the context cue. Where repeat errors are made it could be said that both cues are followed, but at the expense of an omission. Thus, if MICE BLACK CHEESE is presented to the right ear and BIG EAT DOG to the left ear a report of MICE EAT CHEESE and BIG EAT DOG shows a following of context on the right ear and of the physical cue on the left but the word BLACK has been omitted

Closer inspection of the lists on which repeat errors appear do not shed any light on the circumstances under which they occur. Commission errors are more difficult to examine than other errors since they are of different kinds: repeat errors, misperceived words which may or may not be due to fusion errors, words which seem to have been guessed and a number which do not appear to be related to the presented words at all. Moray and Barnett (1965) assumed that such errors arose from two sources, at input and at retrieval. They showed that both the input variable of presentation rate and the retrieval strategy affected the number of commission errors and that there was a significant interaction between the two factors, but this finding does not explain the origins of these errors.

Overall, the main finding from this first experiment was that on crossed context lists, switched responses were more common than correct responses. As far as the method of scoring is concerned, as more data is required by the scoring method the frequency of switched responses is found to be greater. Crossed context lists affect the perception or retrieval of first and third words, as well as the middle words, with higher omission and commission errors found than on straight context lists. Within ear errors, ie. errors within a half-set do not seem to be affected by the crossed context.

Certainty Judgements

In addition to the main thrust of the experiment subjects were also asked to indicate at the end of each list whether or not they were certain that what they had written was correct. Subjects were specifically asked to ignore their own omissions when making these judgements so that the data would reflect only the positioning of words. Unfortunately subjects quite often omitted to mark certainty, particularly at the start of the session. The frequencies given in the following tables are therefore the total number of certainty and uncertainty judgements made by all subjects over all lists. Table 9 shows the responses to the two types of list without reference to the responses which were made.

Table 9 : Frequency of certain and uncertain responses to straight context and crossed context lists.

| | Straight Context | Crossed Context | Total |
|---|---|---|---|
| Certain | 141 | 85 | 226 |
| Uncertain | 35 | 97 | 132 |
| Total | 176 | 182 | 358 |

Clearly, subjects were less certain of their responses to crossed context than to straight context lists, and this was confirmed by analysis of variance between list types and certain and uncertain responses. The interaction between the two factors was significant. $F(1,7) = 188.37$ $p < .01$. The ANOVA summary table is shown in Appendix 1.2.

Table 10 shows the certainty judgements in relation to the responses which were made to the lists. Both omission and commission errors are ignored for the purposes of this table.

Table 10 : Percentage of certain and uncertain responses to crossed context lists (a) when the words were recalled in the correct order (b) when a switched response occured and (c) when another order error ocurred.

| | (a) Correct | (b) Switched | (c) Other | Total |
|---|---|---|---|---|
| Certain | 16.67 | 26.04 | 1.56 | 44.27 |
| Uncertain | 19.27 | 27.6 | 3.65 | 50.52 |
| (No Response) | 2.08 | 2.6 | 0.52 | 5.21 |
| Total | 38.02 | 56.24 | 5.73 | |

It seems clear that subjects were no more uncertain of their responses when they were reported in switched order than in the order presented (correct). This seems to strengthen the argument that subjects are unaware that they are following the context cue and believe that they are reporting the words as presented although the data in Table 9 show that overall, the crossed context lists do lead to greater uncertainty.

It has been suggested that subjects may be unable to ignore their own omissions, basing their judgement only on the positioning of words. This is given some credence by the data given in Table 11 which indicate that the ratio of certain to uncertain judgements does decrease as the number of omissions per list increases. Where no omissions occur subjects are twice as likely to record certain than uncertain but where omissions do occur the uncertain exceed the certain judgements. This underlines the problems in using an introspective technique but does not necessarily alter the conclusion that subjects are no less certain of their response when they follow the semantic cue than the physical cue, and may lend weight to the argument that the process whereby either the context or the physical cue is followed, is an unconscious one.

Table 11 : Frequency of certain and uncertain responses to crossed context lists when there are no omissions or between one and four omissions in the list.

| Number of Omissions | None | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| Certain | 35 | 21 | 14 | 9 | 6 |
| Uncertain | 17 | 23 | 21 | 28 | 8 |

Experiment 2 : Introduction

Evidence that subject's expectations may influence their perceptions was reviewed in chapter 1, and it was clear from the early experiment of Treisman (1960) that contextual expectation will influence subjects' responses, perhaps in an unconscious fashion. In the first experiment subjects expect to hear a phrase in each ear for two reasons: because their entire experience leads them to expect that words will follow each other in context and secondly because half of the lists presented (the straight context lists) conform to that general expectation. Experiment 2 was designed to investigate the effect of altering their immediate experience and therefore expectations by presenting less meaningful material than the straight context lists, to see if this reduced the number of switched responses to crossed context lists. By presenting disordered context messages to each ear it was also intended to show that subjects were not consciously re-ordering lists in order to maintain context.

Method

Eight subjects were tested. The stimulus material differed from that used in Experiment 1 in only one respect. The crossed context lists remained the same but the straight context lists were altered so that they no longer made sense although the words from each phrase were still presented to each ear

eg. Far From Home becomes From Far Home The lists were
King And Queen Queen King And

designated disordered context lists.

The use of the same lists meant that many of them still retained high association value (eg. Queen King And) but they are less likely to be perceived as a unit. The ways that the straight context lists could be disordered were constrained in that some reorganisations of the lists still resulted in a meaningful phrase and some possible pairs of words were too similar in sound to be presented as a pair. The phrases were therefore disordered in such a way as to make minimum sense without interfering with words presented simultaneously. The lists were recorded and presented in the same way and in the same order as that used in Experiment 1.

Results

The same response types as those found in Experiment 1 were identified. The equivalent percentage scores are given in Table 12. Omissions were analysed in the same way, using analysis of variance. The results showed no significant difference between lists, $F(1,7) = 0.03$. A significant difference was found between positions $F(2,14) = 19.13$ $p < .01$ and the List x Position interaction was also significant. $F(2,14) = 30.29$ $p < .01$. The ANOVA summary table is given in Appendix 1.3. The Scheffe test was carried out to compare the treatment sums and Table 13 shows the results of these comparisons.

Table 12: Mean percentage of words presented in each position from disordered context and crossed context lists which were recalled in different positions or omitted.

| Lists | Disordered Context | | | Crossed Context | | |
|---|---|---|---|---|---|---|
| Positions | 1 | 2 | 3 | 1 | 2 | 3 |
| Omissions | 26.04 | 29.69 | 26.04 | 25.26 | 39.06 | 16.15 |
| Correct | 69.79 | 66.41 | 71.61 | 72.4 | 30.47 | 80.21 |
| Switched | 1.04 | 0.52 | 1.04 | 1.82 | 29.95 | 2.08 |
| Within Ear Error | 2.61 | 2.34 | 1.3 | 0.52 | 0.52 | 1.04 |
| Error Within & Between Ears | 0.52 | 1.04 | 0. | 0. | 0. | 0.52 |
| Commissions | | | | | | |
| Misheard | 4.17 | 3.91 | 6.77 | 3.39 | 5.47 | 3.65 |
| Guessed | 0.78 | 1.3 | 0.52 | 2.35 | 3.63 | 2.08 |
| Miscellaneous | 0.52 | 1.83 | 0.52 | 2.86 | 5.22 | 0.78 |
| Repeats | 0.26 | 1.04 | 0.26 | 0. | 3.92 | 0. |
| Total Commissions | 5.73 | 8.08 | 8.07 | 8.6 | 18.24 | 6.51 |

Table 13 : Individual comparisons of each word position between and within disordered and crossed context lists : Omissions

| | Positions | Disordered Context 1 | Disordered Context 2 | Disordered Context 3 | Crossed Context 1 | Crossed Context 2 | Crossed Context 3 |
|---|---|---|---|---|---|---|---|
| Disordered Context | 1 | | NS | NS | NS | | |
| | 2 | | | NS | | • | |
| | 3 | | | | | | • |
| Crossed Context | 1 | | | | | • | • |
| | 2 | | | | | | • |
| | 3 | | | | | | |

Within disordered context lists no differences were found between omission rates on the three positions, a similar result as in experiment 1 with straight context lists. On crossed context lists all three positions differed significantly also as found in experiment 1. Comparison of the two list types indicated no significant difference on position one but significant differences were found on second and third position words. Reference to Table 12 shows that crossed context lists had a larger number of omissions on position two and a smaller number on position three than the disordered context lists.

In contrast reference to Tables 5 and 6 on pages 59 and 60 show that, there was no significant difference between omissions on straight and crossed context lists on the third position, but significantly more omissions on crossed context lists on positions one and two. This discrepancy is evaluated further in the discussion section.

Reference to Tables 5 and 12 also indicates that disordered lists appear to produce results more like those on crossed context lists than on straight context lists, particularly in terms of omissions, correct responses and commissions. They also produce a higher rate of within-ear errors than either straight or crossed context lists. However, this tendency to re-order the lists was slight and in no case resulted in both phrases from a list being recalled as if they were straight context. Neither were there ever more than two words in one list of six words re-positioned in this way.

Comparing this experiment and the first there appear to be few differences in responses made to crossed context lists with the exception of switched and correct responses to second position words. The number of these switched responses were compared using the Mann-Whitney U test. No significant difference was found between the rate of switching in the two experiments ($U = 20$ $p = 0.117$). The number of crossed context lists from which all six words had been recalled with the second words switched was also compared with the corresponding data from experiment 1. Again, no significant difference in the number of switched responses was found, $U = 21$ $p = 0.139$. Table 14 gives the mean percentage of these lists.

Table 14 : Mean percentage of lists from which all six words had been recalled (a) in the correct positions (b) with the second position words switched (c) in some other positions.

| Lists | Correct | Switched | Other | Total |
|---|---|---|---|---|
| Disordered Context | 34.38 | 0 | 3.125 | 37.5 |
| Crossed Context | 11.46 | 15.1 | 0 | 26.56 |

## Certainty Judgements

The judgements made by subjects of whether they were certain or uncertain that what they had written was correct were examined in the same way as in Experiment 1. Tables 15 and 16 give these results.

Table 15 : Frequency of certain and uncertain responses to disordered context and crossed context lists.

| | Disordered Context | Crossed Context | Total |
|---|---|---|---|
| Certain | 104 | 88 | 192 |
| Uncertain | 80 | 100 | 180 |
| Total | 184 | 188 | 372 |

An analysis of variance was carried out on these data in the same manner as experiment 1. No significant differences were found, indicating that subjects were no more certain of their responses to disordered context lists than to crossed context lists. The ANOVA summary table is presented in Appendix 1.4. Table 16 indicates that there is little difference in certainty judgements, depending on the response type, from that found in experiment 1 although there is a slight tendency towards fewer uncertainty judgements when responses are switched.

Table 16 : Percentage of certain and uncertain responses to crossed context lists (a) when the words were recalled in the correct order. (b) when a switched response occurred and (c) when another order error occurred.

| | (a) Correct | (b) Switched | (c) Other | Total |
|---|---|---|---|---|
| Certain | 20.83 | 24.48 | 0.52 | 45.83 |
| Uncertain | 23.44 | 22.4 | 6.25 | 52.09 |
| No Response | 1.04 | 1.04 | 0 | 2.08 |
| Total | 45.31 | 47.92 | 6.77 | |

Discussion

No significant difference between experiments one and two were found as far as the number of switched responses were concerned, either when measured item by item or by all correct lists. However, there were some indications that responses to crossed context lists did differ in this experiment as compared to experiment 1. There was a reduction of 8% in the rate of switching and a corresponding increase of 6% in the number of correct responses. Apart from this anomaly all the results for crossed context lists shown in Table 12 are within 2% of those shown in Table 5 for experiment 1.

Comparison of all correct lists in the two experiments also revealed no significant difference but reference to tables 7 and 14 give an indication of rather different results. In experiment 1, 5.21% of the lists were recalled in the correct order and 22.92% in the switched order; one correct list for every 3.67 switched. In experiment 2 the number of lists in correct order more than doubled to 11.46% while switched lists dropped to 15.1%; one correct list for every 1.31 switched list.

In both experiments the number of omissions on the last word of the crossed contex lists was significantly lower than on the first and second positions and this can be ascribed to a recency effect. Though not significant, results on straight context lists did not show this effect, third position words having the same number of omissions as the first-position words, and those first position words show a similar number of omissions as on crossed context lists in both experiments. It therefore appears that the ongoing context of straight and crossed context lists gives a benefit to the third position which disordered context does not enjoy but that the disordered and crossed context do not experience these benefits on first position words. It can therefore be proposed that processing of the straight context first position words is enhanced by the unambiguous contextual information which it receives. This, again, suggests a reconstructive process where later information can be utilised to resolve indecision about earlier information. In the case of straight context this is beneficial but in the other two list types the incoming information is too ambiguous to be of benefit. The first position words in disordered and crossed context can therefore be viewed as showing a "true" omission rate, perhaps more similar to that which would be found with unassociated words while the straight context lists show "enhanced" processing because of the presence of unambiguous contextual and spatial information.

The results of the certainty judgements indicate that disordered context has the same kind of effect as straight context on the subjects perception of the crossed context lists. As in experiment 1 they were no less certain of their responses to crossed context lists when they were switched than when they were correct. However, in contrast to experiment 1 they were no more certain of their responses to disordered context than to crossed context lists.

Although there were no significant differences between the rate of switching in the two experiments the decrease in switched responses as compared to correct responses when Broadbent's scoring system was used was sufficiently great that it was felt that some control of this factor should be exercised in future experiments and that it was worthy of further investigation in its own right. Experiment 8 was therefore designed, in part to examine this further.

There was little evidence that subjects re-positioned the items in disordered context lists in the way that they did on crossed context lists. There were more within ear errors on disordered context lists than the other two list types but less than 3% of responses were this kind of error as opposed to nearly 30% switched responses to crossed context lists. It would therefore seem that the "position tags" are less likely to be lost than the "ear of arrival tags" and that subjects do not consciously try to re-order incoming information into context. The disordered context lists are further investigated in experiment 6.

In this experiment the experimental manipulation was designed to alter the contextual expectations of the subject by changing the information which was presented contiguously with crossed context lists. In the following experiment the information within the crossed context lists themselves was altered to give an experimental task, similar to that of Warren and Warren (1970).

Experiment 3 : Introduction

It is clear that some word guessing occurs from the incidence of incorrect guesses found within commission errors. Presumably some "correct" guesses are also made and included in the switched response category. It is not often possible, of course, to say whether or not a subject consciously guesses or unconsciously reconstructs a word which he has failed to hear. A response of Big White Dog when Big Black Dog has been presented has clearly involved a process of conscious guessing of a word which will fit the context but other responses, such as Big Brown Dog are less clear cut since the first consonants of Brown and Black are the same.

The third of this series of explanatory experiments looked at the extent to which switching occurred when more ambiguous material, which sounded like the crossed context lists was presented. The studies of, for instance, Goldiamond and Hawlkins (1958) and Warren and Warren (1970) suggest that subjects will perceive a word in context even when there is degraded acoustical evidence or, indeed no acoustical evidence for doing so. In this experiment the middle items of the crossed context lists were manipulated so as to provide degraded acoustical evidence of context to see how far subjects would reconstruct the original context.

<u>Method</u> : 6 subjects were tested. The stimuli differed from that used in experiment 1 in only one respect. The middle pair of words in the crossed context lists were altered so the words did not make sense as phrases but had a similar sound. For instance where

| | | |
|---|---|---|
| Far | And | Home |
| King | From | Queen |

was presented in experiment 1, in this experiment

| | | |
|---|---|---|
| Far | Land | Home |
| King | For | Queen |

was presented.

As far as possible only one consonant was altered but in some cases (such as 'From' to 'For') this was impossible to accomplish without creating nonsense syllables or very uncommon words. The straight context lists and order of presentation were the same as in experiment 1.

Results and Discussion

Only the second position words from the crossed context lists were examined. Table 17 gives the percentage of these words which were reported in different ways.

Table 17 : Mean percentage of 2nd position words from crossed context lists recalled (a) as presented (b) as the original context word in the presented position (c) as the original context word in the context position (d) omitted (e) showing a commission error. Examples of (a), (b) and (c) are given below and equivalent scores from experiment 1 are given in brackets.

| (a) | (b) | (c) | (d) | (e) |
|---|---|---|---|---|
| 23.96 | 5.73 | 17.71 | 51.56 | 29.69 |
| (24.74) | | (38.02) | (36.2) | (16.15) |

Examples

| (a) R | (a) L | (b) R | (b) L | (c) R | (c) L |
|---|---|---|---|---|---|
| Far | King | Far | King | Far | King |
| Land | For | And | From | From | And |
| Home | Queen | Home | Queen | Home | Queen |

The figures shown in brackets are the approximate equivalent percentages from experiment 1.

The pattern of responses was quite different in this experiment with a high rate of both omissions and commissions being recorded. The commission errors were the most frequent responses and were even more difficult to categorise than in the previous two experiments. There were many responses which were neither the presented nor the original context words but which incorporated consonants and/or vowels which had been presented and which also made sense. For instance

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| where | Mice | Sack | Cheese | was presented (originally | Mice | Black | Cheese) |
| | Big | Beat | Dog | | Big | Eat | Dog |

responses of Mice Like Cheese, Mice Seek Cheese, Big Bad Dog and Big Fat Dog were recorded (commissions) as well as Mice Eat Cheese and Big Black Dog (switched responses). In these situations one cannot say that subjects were only guessing the words since there were some phonetic cues present as well as contextual cues which led to these commission errors. The 17.71% of words which were reported as the original words (eg. Eat and Black) in the switched position are those which were expected and give a rate of switching that is less than half that found in experiment 1.

Overall it would appear that subjects continue to actively and/or passively seek words which will fit the context of the first and third words where even degraded evidence exists that this is correct. These responses occur at the expense of a higher omission rate but not, apparently, correct responses.

**Experiment 4 : Introduction**

This experiment is of a somewhat different nature to the first three in that it was designed to investigate a problem of a methodological nature. It is included here since it may also be regarded as an exploratory experiment and because the same stimulus lists were used in order that some comparison could be made with experiment 1.

Broadbent and Gregory (1964) noted that recall of lists of the Gray and Wedderburn type is much poorer than recall of digit lists. The omission rates on crossed and disordered context lists as compared with straight context lists indicate that this is a problem associated with both disordering of context between and within ears. This high rate of omissions causes various problems in the study of responses to such lists. As Broadbent and Gregory (1961) pointed out, we cannot know what task the subject is performing once errors appear. Moray and Barnett (1965) used digit lists in an attempt to overcome the problem of omission and commission errors. They used only the digits one to six, reasoning that the task would be one of ordering the stimuli since subjects knew in advance which digits they would hear. However, they found a higher number of omission errors using this paradigm than when a larger set of digits had been used. It seemed that subjects were unwilling to respond at all if they were not certain of the order even though they certainly knew what the stimulus was.

Broadbent's method of scoring avoids the problems of omission and commission errors by scoring only those lists from which all six words have been correctly recalled but this means that a large amount of potentially useful data is discarded. For instance, in experiment 1, 70% of the data are immediately discarded. The problem then is that of presenting such lists in such a way as to minimise omissions and commissions. The method chosen here is analogous to the probe techniques commonly used in visual memory experiments. (eg. Sperling 1960). Yates (1972) used such a method in an auditory experiment. He presented dichotic lists of items and at the end of every list presented a visual display which indicated the ear and position from which a particular word was to be recalled. Probing in this way is not, of course, likely to reduce omission and commission errors but a reversal of this procedure, where a word is given and its position asked for, might do so. Murdock (1967) has shown that in an auditory task recognition is better when the probe item is also presented auditorily rather than visually. Mewhort (1973) used this technique in a dichotic listening experiment and it is used similarily here.

This procedure does not answer Broadbent's argument since omissions and commissions are no doubt occurring but not being recorded. However the technique may allow the "response" end of processing to be tapped, under the assumption that the task requires the positions of the words to be drawn from a memory store.

## Experiment 4

### Method

17 subjects were tested. The stimulus lists were identical to those used in Experiment 1, consisting of straight and crossed context lists. They were presented in the same order as in Experiment 1. At the end of each list there was a pause of one second and then two of the six words were repeated binaurally. One of the two words was always a second position word and the other either a first or third position word ie. subjects would hear :

| | | | | | | |
|---|---|---|---|---|---|---|
| Right Ear | Mice | Black | Cheese | (1 sec pause) | Black | Dog |
| Left Ear | Big | Eat | Dog | (1 sec pause) | Black | Dog |

First and third words were required equally often and half of these were required from the same ear as the second position word and half from the other ear.

Following each list there was a five second interval during which subjects made their responses. Instructions to subjects were that they should write down the repeated words in the positions in which they had heard them. The response sheets were identical to those used in the first three experiments. The subjects were also asked to indicate if they were certain or uncertain that their positioning of these words was correct.

Results

In spite of the fact that the words to be positioned were provided, omission and commission errors did occur. In this context an omission error was recorded where one of the presented words did not appear on the response sheet. On some occasions only one of the required words was responded to and on others a word which had been presented but which had not been repeated at the end of the list was recorded. There were no obviously guessed or miscellaneous commission errors but misheard commissions did occur. Inspection of the data showed little difference between first and third position words so these data are combined in Table 18 which shows the percentage of response types to crossed context lists.

Table 18 : Mean percentage of words from crossed context lists which were recalled in different positions, omitted or showed commission errors. The corresponding data from Experiment 1 are shown in brackets.

| Responses | Position 2 | | Position 1 & 3 | |
|---|---|---|---|---|
| Omitted | 17.4 | (36.2) | 10.54 | (21.1) |
| Correct | 20.34 | (24.74) | 73.77 | (76.3) |
| Switched | 53.19 | (38.02) | 12.25 | (1.43) |
| Within Ear Error | 3.43 | (0.26) | 1.96 | (1.04) |
| Error Within and Between | 5.64 | (0.78) | 1.47 | (0.13) |
| Commissions | 4.9 | (4.17) | 2.45 | (4.95) |

On all positions the number of omissions was approximately half of those found in Experiment 1 and on all positions there was a small decrease in correct responses. On position 2 words the percentage of switched responses was 15% over the rate in Experiment 1 but there was also an increase of 10% on positions 1 and 3. Other position errors were also higher, particularly on position 2 words. Once again the switched response was the most common response to second position words.

The results of the certainty judgements are given in Table 19. A direct comparison with Experiment 1 is impossible and the data given is based on the response to the second position words only.

Table 19 : Percentage of certain and uncertain responses to crossed context lists when the second word was (a) positioned correctly (b) switched (c) positioned in some other way. Approximate equivalent scores from Experiment 1 are shown in brackets.

| | (a) Correct | | (b) Switched | | (c) Other | | Total | |
|---|---|---|---|---|---|---|---|---|
| Certain | 13.73 | (16.67) | 37.25 | (26.04) | 10.54 | (1.56) | 61.52 | (44.3) |
| Uncertain | 5.88 | (19.27) | 12.5 | (27.6) | 7.84 | (3.65) | 26.22 | (50.52) |
| No Response | 0.74 | (2.08) | 3.43 | (2.6) | 8.09 | (0.52) | 12.26 | (5.21) |
| Total | 20.34 | (38.02) | 53.19 | (56.24) | 26.47 | (5.73) | | |

Overall, there were fewer uncertain responses recorded than in Experiment 1 and this reduction appears to have been approximately equal on those responses which were correct and those which were switched, in both cases about 14%.

Discussion

This method of eliciting word positions does not eliminate omission and commission errors, as was hoped. Although the method was different it may be that the same kind of process operated here as was suggested by Moray and Barnett (1965). Although the subjects are made aware of the words which they are being asked to recall, if they cannot remember the position they may be unwilling to write the word at all or may omit words about which they are undecided when the next list starts. It is possible that this tendency might be overcome using a visual rather than auditory probe but the possible advantages of this might be offset by the effect of using a different sense to present the probe word.

At first sight, it appears that there was a much higher percentage of switched responses in this experiment in comparison with experiment 1. However this is true both of second position words and of first and third positions. A more truly comparable figure for the rate of switched responses is probably that shown in the total of column (b) in Table 19 which gives the percentage of lists in which a switched response occurred. The equivalent total from experiment 1 shown in Table 10 is 56.24%, only slightly higher than the 53.19% found in the present experiment.

Examination of the different pattern of scores in this experiment in comparison with the first experiment indicates that the drop in omissions and correct responses results in an increase of all other errors, but predominantly switched responses. Clearly if these responses were made through a process of random guessing one would expect an increase in all categories of responses, including correct responses. As already noted the increase in switched responses was also true of words on positions 1 and 3 and so the data were further examined to ascertain whether or not there was a relationship between the responses made to the two required words. Looking at the 12.25% of switched responses to positions one or three it was found that over half of these (6.37%) were made when position 2 words were reported in the correct position, 4.41% occurred when there were omissions or other errors and 1.47% when the second word was itself switched. One can therefore hypothesise that the first and third words were positioned with regard to the decision which had been made about the position of the second word and this is given some credence by the finding that 50% of the first and third words which were switched when the second position were correct were third words required from the side opposite that of the second word, eg. when "Eat" and "Cheese" were required from

| | | |
|---|---|---|
| Big | Eat | Dog |
| Mice | Black | Cheese |

Finally, the results of the certainty analysis also raise some interesting questions. Strictly speaking, the certainty judgements in the two experiments cannot be properly compared since the scores reported in experiment 1 refer to lists in which a switched response occurred and in experiment 4 to two individual words. However the data in Table 19 strongly indicate that subjects in experiment 4 were more certain of their responses than those in experiment 1 and in particular were more certain of their switched responses. It may be that the lower rate of omissions contributes to this difference since there was some evidence in experiment 1 that, contrary to instructions, subjects were influenced by omissions. In view of the fact that all responses produced more certain than uncertain judgements it is likely that the different requirements of the task, merely in terms of the number of words required were responsible for differences found between the two experiments.

## General Discussion

As would be expected there is very little interference between the two messages with straight context lists as subjects have not only a physical cue for grouping, but also the semantic cue. With crossed context lists interference is much greater and results in a higher rate of omission and commission error not only at the point where the semantic confusion occurs, but apparently exerting a retroactive effect upon the words in the first position, while third position words on crossed context lists are recalled as accurately as in straight context lists. The results of experiment 2 show that these results are not due solely to the crossing in the crossed context lists. Disordered context lists show a similar rate of omissions but no difference between the three positions. Therefore the lower rate of omissions on third position words cannot be solely due to a simple recency effect since, in that case the disordered lists would show a similar result. It seems, therefore, that the context has a facilitating effect on recall of the third word while the crossing of ears, has an inhibiting effect on the second position words. The retroactive effect is shown both on disordered context and crossed context lists but not on straight context lists. This suggests that subjects "reconstruct" their perception of the first word on lists which are unambiguous. The ear of arrival and semantic cue makes this a straightforward task, which may be carried out consciously or unconsciously. For instance subjects who have picked up a few features of the first word and heard "eat cheese" in the second and third positions may make a conscious decision that the first word was probably "mice". Alternatively the information gained from the second and third words may allow the unit corresponding to the word "mice" to fire. In some cases, as is indicated by the varied responses, particularly in experiment 3, to ambiguous words, the first kind of conscious reconstruction takes place, so that subjects report " Big White Dog" when "Big Black Dog" has been presented, while accurate report may indicate unconscious or conscious processes, or most likely a combination of both. Although single channel theories in particular have often been presented as if information flows through the organism from input to output with no flow back from later to earlier stages, it has long been recognised that there must be mechanisms able to "check back" on inputs (eg. Becker (1976)). Without such an ability there would be no difference in omission rates between the disordered and crossed context lists and the straight context lists. The reconstructive process is clearly hampered in disordered and context lists because the information is less unambiguous (less clearly tagged) than in straight context lists.

The different methods of scoring these experiments yield interesting results. It seems that where all necessary information is available the central processor is much more likely to "choose" the semantic cue, than the physical one, even though the instructions to "write down what you heard in your right ear under R and what you heard in your left ear under L" ought to bias the subjects towards using the physical cue and keeping the information separate. Clearly in straight context lists the input and output transmission lines are quite easy to keep apart while in crossed context lists they are not. This result can be viewed alternatively that fewer omissions and other errors occur when the semantic cue is picked. This is contrary to Broadbent and Gregory's (1964) argument that it is equally difficult to switch from category to category as it is from ear to ear. These results indicate that semantic recall is more efficient than ear by ear with crossed context lists. It should be remembered at this point that Broadbent and Gregory (1964) were referring to order of <u>report</u> rather than order of <u>recall</u>.

Disordered context lists show little tendency to be re-ordered in the way that crossed context lists do and are apparently little more subject to intrusions from the other ear than straight context lists. This indicates that the temporal position tags retain greater importance or discriminability than do the ear position tags, when messages of this kind are presented. Mewhort (1973) also found that this was the case when subjects were asked to identify the ear and position of dichotically presented digits and letters. The temporal position information was always more accurate than that of ear of arrival. So we cannot think of the six words being present in memory all tagged with ear of arrival, temporal position and semantic information, with a retrieval mechanism choosing to follow the semantic cue because it is most important. Clearly the temporal arrival of information overrides the semantic cues in disordered context lists in a way far greater than the ear of arrival information is able to do with crossed context lists. In the straight context lists the temporal information is more discriminable, just as ear of arrival is, because of the context.

The lower rate of omissions on straight context words in the first position and the results of experiment 3 indicate the probabilistic nature of word recognition. From the work of, for instance, Reicher (1969), Warren and Warren (1970), Wheeler (1970) and Broadbent and Broadbent (1975) it is known that people will perceive degraded words which are highly probable within a given context and/or are common words in the English language (word frequency effect). The high rate of omissions on crossed context lists in experiment 3 confirms that the further loss of context by changing the phonemic structure of the critical words makes these lists more difficult to perceive than even the disordered context lists. However 23% of the second position words were recalled as the original context word and when this occurred subjects were three times more likely to recall it in the switched position. So there seems to be two aspects of the effect of probability; identification of the word itself and identificatio of the position of the word.

As regards experiment 4 it appears that the probe paradigm produced fairly similar results to that of experiment 1 in terms of the number of lists in which a switched response appeared. The percentage of switched items was however much higher and over two and a half times higher than the correct responses. There was in fact a smaller percentage of correct responses than in experiment 1. Leaving aside the reason for omissions we can see that the drop in omissions and in correct responses accounts for an uneven distribution of higher percentage errors: switched responses being 15% higher, within ear errors being 3% higher and errors of ear and position being 5% higher than in experiment 1.

In theoretical terms, when the critical words are repeated at the end of a list it allows recognition of a word which would otherwise have been omitted. If it does not allow recognition then the word may be omitted even though the subject knows what the word is because of its re-presentation at the end of the list. The decision about where the word is to be placed then has to be made, and, in what can only be a retrieval process, the decision appears to become even more biassed towards the semantic cue. If this process involves scanning all the material in a retrieval store (a) to see which words in store correspond to those required (b) to see where the other words were placed and where the required words were placed, this may be equivalent to carrying out a rehearsal or re-processing the material in store. This processing enhances the semantic cue even further, either because the re-presented word gives back information which was lost or because the reprocessing itself confirms the view. In the former either the system or the individual will work on the probabilities of the different inputs which clearly point to the semantic cue.

The finding that first and third position words also have a higher rate of switched response is harder to explain but there is some evidence that the decision on positioning depends partly on decisions already made, about the positioning of earlier inputs. Also in both experiments 1 and 2 the third position words showed more switched responses than position 1, though still to a minimal extent.

Finally, as far as the results of the certainty judgements are concerned, subjects seem subjectively less certain when crossed context lists are presented than straight context lists but no less certain than they are on disordered context lists. However, they are no less certain of their responses when the decision is made to follow the semantic cue rather than the physical cue on cross context lists. These judgements may be partly based on omissions although subjects were told to make their judgements only on the positioning of the words. Subjects also frequently forgot to make certainty judgements and it is probably not a useful addition to this kind of task. The later experiments did not therefore ask for this information.

In conclusion, this paradigm has shown its usefulness on many occasions since the early split span experiments and does so again in the preceding experiments. There are, obviously, some drawbacks to its use. Where three words are presented to one ear and three to another in this way, it is not possible to examine the processes taking place, in the order of milliseconds,which allow the ordering and reordering of the information to be presented in the output. It is possible to infer some processes from the eventual response given and to that extent is little different from other methods which examine the effect of semantic content.

Examination of different methods of scoring responses may allow this to take place to a greater extent than suggested by earlier experiments.

# STRUCTURAL AND FUNCTIONAL FACTORS AFFECTING SELECTIVE RESPONSE TO COMPLEX AUDITORY INPUT

## Chapter 5. Presentation Rate, Word Position and Responses to Crossed Context and Category Lists.

# STRUCTURAL AND FUNCTIONAL FACTORS AFFECTING SELECTIVE RESPONSE TO COMPLEX AUDITORY INPUT

Chapter 5. Presentation Rate, Word Position and Responses to Crossed Context and Category Lists.

**Experiment 5 : Introduction**

Presentation rate has been a variable of interest both in straightforward memory span experiments and in dichotic split span tasks. One of the first, in dichotic tasks was that of Broadbent (1954). Using digit lists he found the classical result that it becomes progressively easier to report items in the order of arrival, that is, pair by pair, as the presentation rate becomes slower. Broadbent said of this finding "that it seems to imply that when attention is shifted away from one channel to another and then back to the first a time interval of between 1 and 2 seconds will be required". Thus it was suggested that the filter in Broadbent's model (1958) could change its setting for selection no faster than once per second. Moray (1960) challenged this interpretation and presented subjects with staggered items, alternating between the two ears rather than simultaneously presented eg.

| | | | | |
|---|---|---|---|---|
| Right Ear | One | | Six | |
| Left Ear | | Three | | Eight |

These could be easily recalled even at a rate of two items per second. Furthermore, he found that not only did pair by pair recall improve as the presentation rate slowed, but that ear by ear recall showed similar improvement. He therefore showed that the idea that the filter needed time in the order of one to two seconds to switch from one channel to another was inaccurate.

It has become clear that the effect of rate of presentation is dependent on numerous other variables. Posner (1963) reviewed studies of presentation rate and found that most showed that a fast presentation rate impaired recall. He concluded that -

> "In general, decreasing the rate of presentation allows subjects more time to organise, perceive and rehearse the material ......... and thus it results in increasing recall".

This is a reasonable explanation of Broadbent's (1954) data, since at presentation rates of between one and two seconds, subjects have time to rehearse items in a pair by pair fashion as the list progresses.

However, it became clear that a fast presentation rate does not always produce poor recall, either in memory span or split span experiments. Mackworth (1965) found that the effect of presentation rate depended both on message length and the organisation of items, in an interactive way. He presented strings of 8, 10 or 12 letters, at a fast rate, one item per 500ms, and a slow rate, 1200ms per item. The fast rate did impair recall as the message length increased and if the items were presented in a non-rythmic manner. However, with rythmic presentation of the items recall was better at the fast rate. So the structure of the input, both in terms of message length and grouping had differential effect on recall.

Posner (1964) proposed that recall might improve with presentation rate in tasks where the order of report is fixed and in tasks which reduce the use of recall strategies. Grouping of items at presentation, as in Mackworth's study can be seen as the latter kind of experimental task. Neisser (1967) has pointed out that fixed report, structured items and short messages provide conditions under which the subject has little opportunity to reformulate items at fast rates and must rely on "echoic" memory rather than short-term memory.

Bryden (1962, 1964) provided further evidence about the effect or presentation rate, list structure, list length and report sequences chosen by subjects when left free to recall the lists in any order they liked. Bryden (1962) investigated the effect of presenting three, four and five digit pairs for recall. From Posner's (1964) proposals one might expect (1) greater accuracy at fast rates with three pairs than five pairs (2) greater accuracy at slow presentation than fast presentation (since report was not fixed) (3) from

Broadbent's (1954) data, that a temporal order of report would be more accurate at the slow rate of presentation than the fast rate. The results showed exactly this pattern of results. In addition, it appeared that subjects reported the lists in the temporal order more frequently at slow rates of presentation than fast, and ear by ear orders correspondingly less.

Bryden (1964) also looked at presentation rate and different kinds of semantically structured lists. The lists he presented were shown in Table 3, on page 46 Subjects were again free to recall the lists in any order they liked. At all rates of presentation (half a second, 1 second and 2 seconds) the switched order of report was employed most frequently with lists similar to the crossed context lists used in the present experiments. It was also employed more frequently at the fast rate of presentation than the slower rates. Bryden did not report the analysis of accuracy at different rates of presentation but it appears that there were more correct responses at the slow rate of presentation on lists of unassociated words and where associations were between simultaneous pairs but, on both straight context and crossed context lists there is evidence that the fast rate of presentation resulted in greater accuracy than the slow rate. This, again, is in line with Posner's (1964) and Neisser's (1967) observation that a fast rate of presentation may increase recall when lists are structured in some way.

Yates et al (1970) and Yates (1972) discuss the effect of structured lists and presentation rate effects. They argued that presentation rate will determine retrieval strategy when stimulus material is unstructured but that the structure of the message will be more powerful than the presentation rate when subjects can impose structure on apparently unstructured material or when there is some structure built into the messages. This conclusion was based on results which showed, as usual, that ear by ear recall was more frequent at a fast rate and pair by pair recall more frequent at a slow rate. Furthermore, when the structure of the message was by ears, ear by ear recall predominated, while pair by pair structure resulted in pair by pair recall. However, structure of message and presentation rate interacted in such a way that showed that structure of the message dominated presentation rate in determining retrieval strategy. Table 20 shows Yates et al (1970) data.

Table 20. Effects of presentation rate and list structure on retrieval strategy. From Yates et al (1970).

| | Retrieval by Ears | | | Retrieval by Pairs | | |
|---|---|---|---|---|---|---|
| List Structure | Fast | Slow | Total | Fast | Slow | Total |
| By Ears | 4.73 | 2.62 | 7.35 | 0.05 | 1.77 | 1.82 |
| By Pairs | 1.5 | 0.71 | 2.21 | 2.3 | 3.26 | 5.59 |
| Total | 6.23 | 3.33 | | 2.35 | 5.03 | |

Bartz et al (1967) had also used "crossed" lists and investigated the effect of rate and word position. The stimulus material consisted of digits and words and recall by category involved switching once or twice in the list.

ie.where Right Ear One Coil Three is presented, recalling
Left Ear Bet Two Good

all the digits first, followed by the words requires two switches of channel

whereas Right Ear One Two Good requires only one switch. When
Left Ear Bet Coil Three

subjects were left free to recall in any order they liked, ear by ear report was always preferred. Recall by category was employed more often at the fast rate of presentation when two switches were required than when only one was required. There was some indication that performance on the one crossing trials differed depending on whether the crossing occurred at the beginning of the list

| | | | | | |
|---|---|---|---|---|---|
| eg. | Right Ear | One | Coil | Good | or at the end |
| | Left Ear | Bet | Two | Three | |

| | | | | |
|---|---|---|---|---|
| eg. | Right Ear | One | Two | Good |
| | Left Ear | Bet | Coil | Three |

Table 21 shows the data concerned. It appears that subjects were more likely to report by type when the crossing was on the second and third words at the fast presentation rate but at the slow rate when the crossing was on the first word.

Table 21 : Percentage of recall by type when the crossing was on the first, second and third words (from Bartz et al, 1967).

| | Fast Rate | Slow Rate |
|---|---|---|
| First Word | 10 | 15 |
| Second Word | 21 | 16 |
| Third Word | 15 | 9 |

These results were not subjected to statistical analysis and it cannot be said whether the data relates to the number of "crossings", or the progression of the lists. Further evidence regarding rate of presentation and word position is provided by Penney (1976). In this experiment four dichotic pairs of unrelated words were presented, followed by two probe items. Subjects were asked to say which of the two items had occurred first or if they had occurred simultaneously. Recognition of the relative positioning was better at slow presentation rates though this result was not statistically significant. Recognition was significantly poorer when the words had been presented simultaneously than when one had preceded the other and Penney (1976) interpreted this result in the same way as Mewhort (1972) that sequential associations (temporal tags) are stronger than associations between simultaneous items (ear of arrival tags). Penney (1976) also found a word position effect in one of the experiments. Recognition of position of items was significantly better when the order of the probe items was the reverse of that presented in the list, than when they were in the same order and this might suggest stronger backward associations between words.

As was made clear in chapter 2 the investigation of the effect of context, of associated words and of category words often seem to have been confused in past dichotic experiments. Yates et al (1970) compare their results on a simultaneous switching task (ie. she to there some) with those of Bartz
( went town are left)
et al (1967) who used three, not four, dichotic pairs of digits and letters, in a successive switching experiment.

The experiments reported in this section have been concerned with variables of presentation rate, list structure and word position and have used recall and probe techniques with stimuli as varied as those of Yates et al (1970) and Bryden (1962). The present experiment was designed to bring these different variables together and, using a probe technique, attempted to investigate presentation rate, word position and different degrees of semantic relatedness. Three main questions provide the focus of the experiment: 1. How is the pattern of responses affected by rate of presentation, and in particular, how are switched responses, as found in the previous experiments, affected? 2. Are responses to crossed context lists the same as responses to other kinds of semantically related lists? 3. Do responses, particularly switched responses, differ depending on the word position?

Method

Twenty four subjects were randomly assigned to two different groups, a slow presentation group and a fast presentation group. The slow presentation rate was 1 word per 1200 milliseconds and the fast rate was 1 word per 400 milliseconds.

Stimulus Material Twenty four different examples of four different list types were presented, each consisting of four pairs of monosyllabic items. The list types were designated Straight Context, Crossed Context, Crossed Category and Nonsense lists. Examples of each are given below in Table 22.

Table 22 : Examples of stimulus lists used in experiment 5.

| Straight Context | | Crossed Context | | Crossed Category | | Nonsense | |
|---|---|---|---|---|---|---|---|
| Please | Blow | Sit | Will | Blue | Rat | Club | Gas |
| Come | Her | In | You | Green | Sheep | Sign | Chair |
| To | A | Come | This | Cow | Red | Your | Smoke |
| Tea | Kiss | Chair | Here | White | Pig | Thin | Here |

The experiment focused on the crossed context and crossed category lists. The straight context and nonsense lists were included to control for any possible expectation effects, signs of which were present in experiment 1, as compared with experiment 2.

The categories of words used in the crossed category lists included colours, animals, trees, fish, countries, fruit, digits and also letters of the alphabet. As can be seen from the preceding examples one pair of words in each crossed context and category list was presented out of context. These transposed words appeared in each position six times so that within each rate (between subjects factor) the 96 lists constituted a four (List type) x four (Word position) within subject design. The 96 lists were presented in random order.

At the end of each list there was a pause of one second and then two of the words were repeated binaurally. In the crossed context and category lists one of these words was always one of the transposed words, half from the right ear and half from the left. These words were designated Critical words. The second words asked for were balanced for position and ear of arrival. These words were designated Other words. Using the crossed context list example given earlier the subject would hear: in his right ear: "Sit In Come Chair", and following a second's pause, "You Come". In the left ear he would hear "Will You This Here", and following the second's pause, "You Come". The probe items were always in the order presented in the lists.

As in Experiment 4 subjects were asked to write the words which had been repeated in the position that they had heard them. At both rates of presentation they were given five seconds to make their response before the warning "ready" which preceded the following list was presented.

Results

Section 1. Responses were divided into correct, switched, within ear errors and errors of both ear and position, as in previous experiments. As was found in experiment 4, omissions also occurred. Table 23 gives these response types for all four lists, though only crossed context and crossed category lists were submitted to full analysis.

Table 23 : Mean percentage of responses to critical words in straight context, crossed context, crossed category and nonsense lists.

| | Straight Context | | Crossed Context | | Crossed Category | | Nonsense | |
|---|---|---|---|---|---|---|---|---|
| | 400 | 1200 | 400 | 1200 | 400 | 1200 | 400 | 1200 |
| Correct | 76 | 78.5 | 40.6 | 51.4 | 36.1 | 41 | 43.7 | 42.4 |
| Switched | 11.1 | 8 | 39.6 | 28.1 | 23.3 | 19.4 | 16.7 | 12.9 |
| Within Ear | 6.3 | 9.4 | 8.3 | 11.5 | 18.4 | 18.7 | 21.9 | 25.3 |
| Ear & Position | 3.1 | 2.1 | 7.6 | 7.3 | 13.9 | 16.7 | 13.2 | 12.1 |
| Omissions | 3.5 | 2.1 | 3.8 | 1.7 | 8.3 | 4.2 | 4.5 | 7.3 |

Crossed context and crossed category lists were compared in three way analyses of variance on correct, switched and position errors on critical words giving a Rate x Position x List design. Table 24 gives the position data for correct and switched responses on crossed context and crossed category lists.

Table 24 : Mean number of correct and switched responses in crossed context and crossed category lists at each position.

| | Crossed Context | | Crossed Category | |
|---|---|---|---|---|
| Position | 400 | 1200 | 400 | 1200 |
| 1. Correct | 2.67 | 2.83 | 2.5 | 2.17 |
| Switched | 2.75 | 2.42 | 1.08 | 1.25 |
| 2. Correct | 1.5 | 2.75 | 1.92 | 2.42 |
| Switched | 2.17 | 1.58 | 1.5 | 1.25 |
| 3. Correct | 2.33 | 3.17 | 1.75 | 1.83 |
| Switched | 2.5 | 1.5 | 1.58 | 1.42 |
| 4. Correct | 3.25 | 3.58 | 2.5 | 3.42 |
| Switched | 2.08 | 1.25 | 1.42 | 0.75 |
| Total Correct | 9.76 | 12.33 | 8.67 | 9.84 |
| Switched | 9.5 | 6.75 | 5.58 | 4.67 |

1. Correct Response

Significant effects of rate $7(1,22) = 4.58$ $p < .05$ and of position $7(3,66) = 7.19$ $p < .01$ were found indicating that there were more correct responses at the slow rate of presentation than the fast rate. The position data indicate that there were more correct responses on the final word than the first three. There was no significant effect of list and no interaction effects: ANOVA summary table is given in Appendix 2.1.

2. Switched Responses

The same main effect of rate $7(1,22) = 6.16$ $p < .05$ was found and a significant effect of list type $7(1,22) = 14.59$ with no significant interactions. ANOVA summary table is given in Appendix 2.2. There were more switched responses at the fast rate on crossed context lists. The number of switched responses on crossed category lists was also oompared with those on nonsense lists, using a t-test. There were not significantly more such responses on crossed category lists. $t = 1.51$ $df = 23$.

3. Position Errors

Position errors were analysed in the same way. Main effects of list $7(1,22) = 44.26$ $p < .01$ and of position $7(3,66) = 9.29$ $p < .01$ were found to be significant. No other significant effects were found. The ANOVA summary table is given in Appendix 2.3 and Table 25 shows the position data for each list.

Table 25 : Mean number of position errors on crossed context and crossed category critical words.

| Positions | 1 | 2 | 3 | 4 | Total |
|---|---|---|---|---|---|
| Crossed Context | 1.5 | 2.75 | 2.16 | 1.59 | 8 |
| Crossed Category | 4.5 | 4.66 | 3.91 | 2.42 | 15.49 |
| Total | 6.0 | 7.41 | 6.07 | 4.01 | 23.49 |

There are clearly fewer position errors on the final word of the lists, and fewer on crossed context than crossed category lists.

Section 2

The correct and switched responses were examined further for each list type, taking into account the responses made both to the critical word and the other word. In previous experiments there were indications that not only were the "crossed" words themselves affected but also that other words in the list appeared to be affected by the crossed context. Responses to other words were therefore divided into correct and incorrect and included in four way analyses of variance with main factors of Rate (400ms and 1200ms) Position (1,2,3 and 4). Critical word responses (correct and switched) and Other word responses (correct and incorrect). It should be noted that where positions are given for Other words, these are the positions to which the/

Critical word was presented since it was the effect of the Critical word on responses to Other words which was of interest ie. in the example :

| | | | | | |
|---|---|---|---|---|---|
| Sit | In | Come | Chair - | Sit | This |
| Will | You | This | Here - | Sit | This |

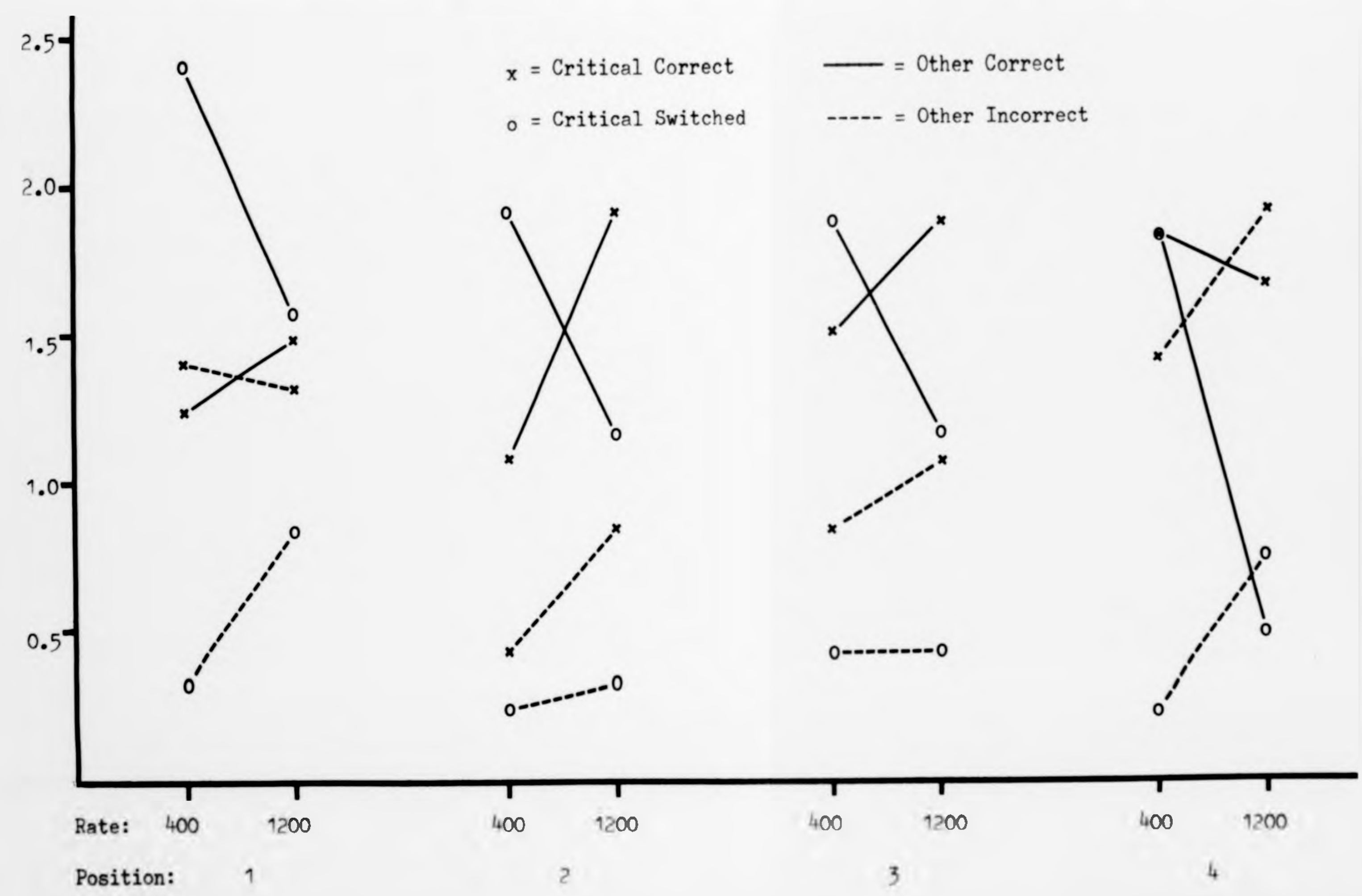
This is the fourth position Critical word and Sit is the fourth position Other word.

1. Crossed context lists (Figure 6)

A four way analysis of variance was carried out on the data shown in Figure 6. Appendix 2.4 gives the full ANOVA summary table. Main effects of Critical word, Other word and Position were all significant. Significant interactions were found between Critical word and Rate, Critical word and Position, and a three way interaction between Critical word, Other word and Position. The four way interaction was also significant $7(3,66) = 7.7$ $p < .01$. Scheffe tests carried out showed that over all positions at the fast rate of presentation switched responses and correct responses occurred equally frequently but that there were significantly fewer switched responses at the slow rate of presentation. Figure 6 shows how the different positions showed different effects, with more switched responses to Critical words than correct responses on position 1 at the fast rate and the number of switched and correct responses becoming closer through positions 2, 3 and 4.

Responses to these lists are clearly determined by a complex interaction of variables in such a way that one can draw only very broad conclusions about what is a more or less probable response given a particular input since not only the specific position of the Critical word and the rate of presentation affect whether a correct or switched response is made, but also what kind of response is made to other inputs. Although the data is presented to show the effect of the Critical word on the Other word it is clear that this is not a one way process

Figure 6: Mean number of responses to Crossed Context lists at each rate and position



and undoubtedly decisions made about the Other word will affect the response to the Critical word as well.

2. Crossed category lists (Figure 7)

A four way analysis of variance was similarly carried out on responses to crossed category lists. Significant main effects of Critical and Other words were found and significant interactions between Critical word and Position $7(1,22) = 3.68$ $p < .05$ and Other word and Position $7(1,22) = 4.66$ $p < .01$. Appendix 2.5 gives the ANOVA summary table and Figure 7 illustrates the data. Comparison of Figure 6 and 7 confirm that the rate effect found on crossed context lists is absent on crossed category lists, as are the complex three and four way interactions. Table 26 shows the significant effects found for each each list type.

Table 26 : Significant effects found on four way analyses of variance on crossed context and category lists.

| Factors | Crossed Context | Crossed Category |
|---|---|---|
| Critical Word | $p < .05$ | $p < .01$ |
| Other Word | $p < .01$ | $p < .05$ |
| Position | $p < .01$ | |
| Critical x Rate | $p < .05$ | |
| Critical x Position | $p < .05$ | $p < .05$ |
| Other x Position | | $p < .01$ |
| Other x Critical x Position | $p < .01$ | |
| Other x Critical x Position x Rate | $p < .01$ | |

Figures 8 and 9 show the Critical word x Position interactions for the two list types. Scheffe tests confirm that there are significantly more correct responses than switched responses on position 4, on both lists. No other comparisons reached the 5 percent level of significance.

Figure 7: Mean number of responses to Crossed Category lists at each rate and position

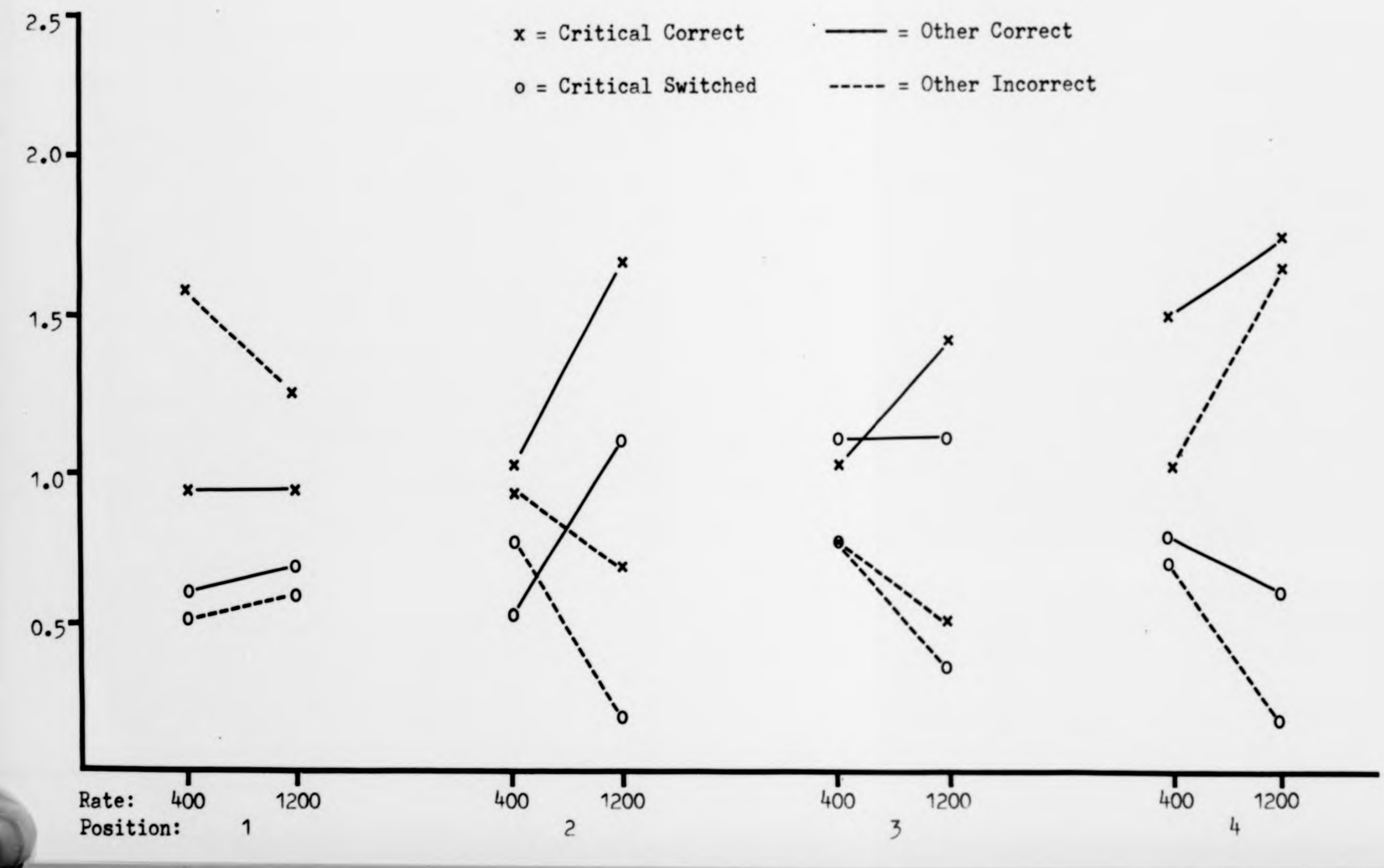


Figure 8: Mean number of correct and switched responses to Crossed Context lists: Critical word x Position

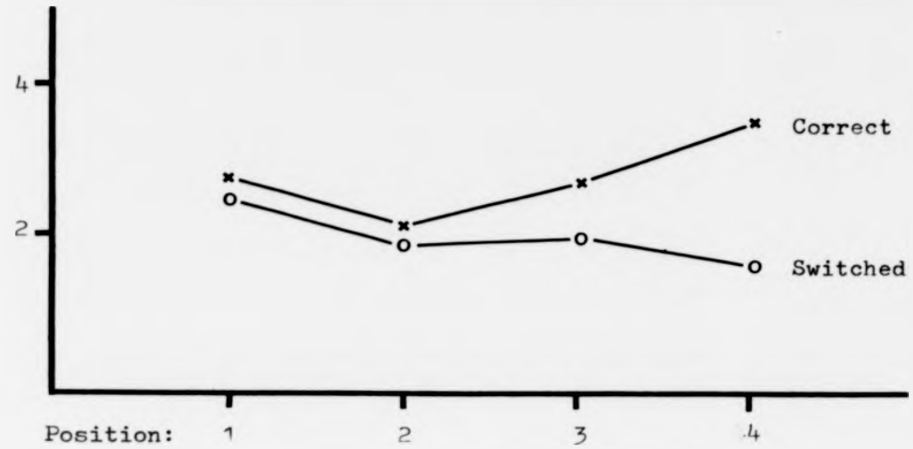
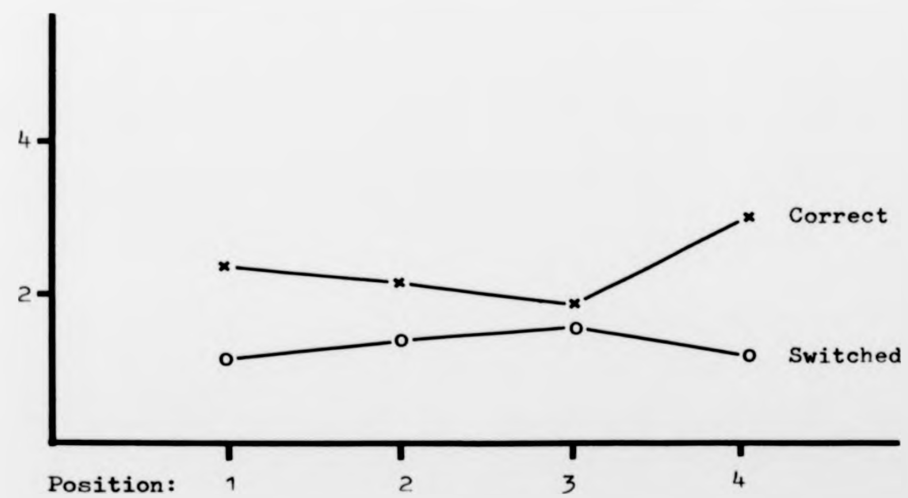



Figure 9: Mean number of correct and switched responses to Crossed Category lists: Critical word x Position



Discussion

The end of the introduction to this chapter posed three questions regarding the effect of rate, of word position and of different kinds of semantic relatedness. The answers to these questions are less straightforward than the questions themselves might suggest since the effects of presentation rate and position have an interactive effect on responses to Critical and Other words, at least on crossed context lists.

Within crossed context lists correct and switched responses to Critical words occurred equally often at the fast rate but there were fewer switched responses and more correct responses at the slow rate of presentation. This is in accord with Bryden's (1964) data which showed a decreasing frequency of switched responses as the presentation rate slowed. Leaving aside the interaction with Other word responses, it is clear that switched responses were less frequent at the slow rate of presentation across all positions but that this was particularly marked on position 4. It appears, then, that the recency effect, whereby there is an increased probability of recall of most recently presented words, applies to the recognition of position as required in this experiment and that it may add to the rate effect in such a way that switched responses are least likely to occur on position 4 at a slow rate of presentation and, even at a fast rate, responses to Critical words on position 4 are as likely to be correct as to be switched.

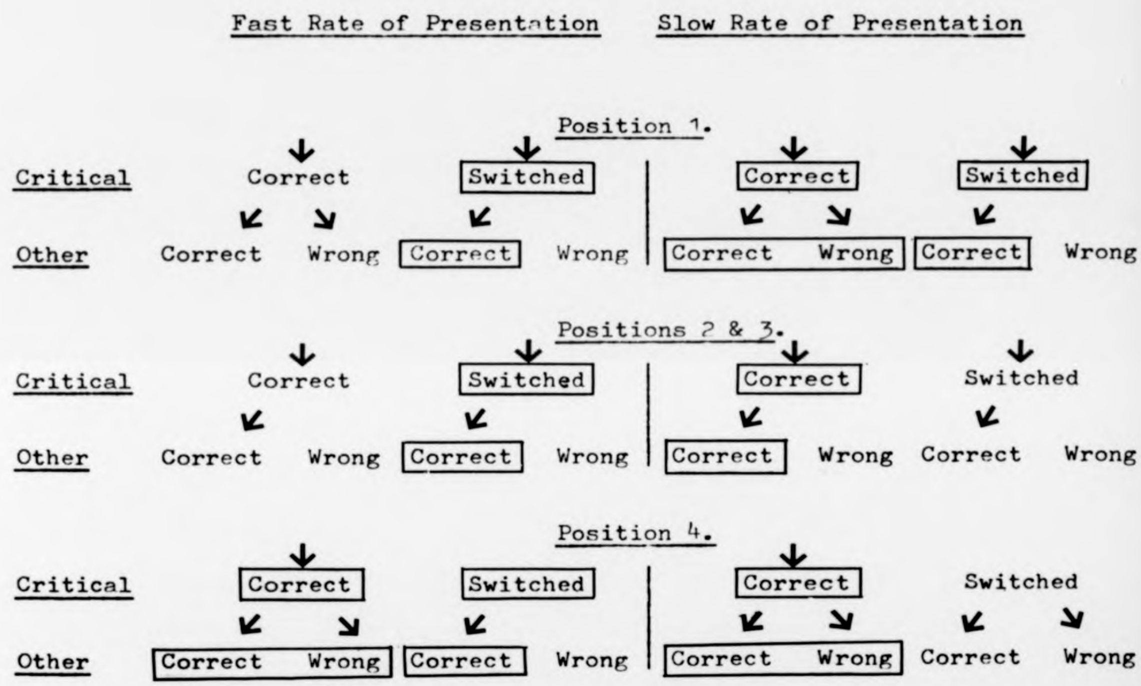
There is little evidence that the number of crossings was an important factor in this experiment. On crossed context lists the second and third positions give similar data, which differ from first and fourth position responses, but first and fourth positions also show different patterns of response. A more coherent framework for the position data is that of a decreasing tendency to show switched responses, with a corresponding increase in correct responses, as the list progresses, ie. the closer the input is to the probe in time, the more likely it is to receive a correct rather than a switched response. This is, however, not necessarily true of crossed category lists. At the fast rate of presentation there are as many switched responses on position 4 as on position 1 and on position 1 there are more switched responses at the slow presentation rate than the fast presentation rate, though these differences are not significant (see Table 24 on page 105 ). These results are however in the same direction as that found by Bartz et al (1967) whose lists more resembled crossed category lists than crossed context lists. However, in section 1 there was no list x position interaction and one cannot conclude that crossed category lists differ from crossed context lists in this respect.

The interaction between Critical responses and Other responses clearly complicates the situation further, so that conclusions drawn about rate and position effects on crossed context lists may be true only when the Other word is correctly perceived. Figure 10 shows how responses to a particular input might depend on rate, word position and responses to Other words. This schematic portrayal of the data given in Figure 6 shows what combination of correct/switched responses and correct/incorrect Other responses appears more probable at each rate and position. The boxes show the more probable combination of Critical and Other responses while the arrows show the more probable response given the input, and given the response to the Critical word. It is worth noting that switched responses to Critical words are nearly always more likely to be accompanied by a correct response to the Other word (the exception being position 4 at the slow rate of presentation). The diagram can also be taken in the opposite direction so that we may conclude that switched responses occur more frequently when Other words are correct.

Figure 10: Schematic portrayal of the results of the 4-way ANOVA on crossed context lists.

↓ = more probable response

☐ = most frequent combination of Critical and Other responses




e.g. At position 1 the Critical word may be correct or switched. If correct, the Other word is equally likely to be correct or incorrect. If the Critical word is switched, the Other word is more likely to be correct than incorrect.

The most frequent combination at the fast rate is Critical word switched and Other word correct.

The interaction effects found on crossed context lists are not found on crossed category lists, with the exception of the Critical word x Position interaction. This may indicate that there are qualitative differences between the two types of list. It is certainly the case that there are quantitative differences, as shown in section 1. It may be that categorised items are processed in a different way from context but the results of this experiment do not allow one to interpret the data in that way. Nevertheless the clear differences between crossed context and crossed category lists confirm the error of using categorised and contextual items as if they had precisely the same effects. As noted in Chapter 2 it appears that this has frequently been the case. It is also the case that crossed category lists do not produce the same pattern of responses as nonsense lists. There are significantly more switched responses on crossed category lists and reference to Table 23 indicates that omissions are also more frequent.

The degree of semantic or contextual constraint appears to determine what kinds of responses will occur. Table 27 shows the cues which are inherent in each list type and where they conflict.

Table 27 : Cues available * within each list type for ear, context and position.

| | Ear of Arrival | | Context/Ear | Context/Position |
|---|---|---|---|---|
| Straight Context | * | = | * | * |
| Crossed Context | * | ≠ | * | * |
| Crossed Category | * | ≠ | * | |
| Nonsense | * | | | |

On straight context lists, where the semantic cue and the cue for ear of arrival are the same, correct responses predominate and there are few errors of either ear or position. Crossed context lists provide a context cue which conflicts with the cue for ear of arrival. The context itself provides a cue to word position and within ear errors occur no more frequently on crossed context lists than on straight context lists. Crossed category lists also provide a semantic cue which conflicts with ear of arrival, but there is no contextual continuity and therefore the only position cue lies in the relative positions of the other words. These lists therefore show more switched responses than straight context and nonsense lists but also have more position errors than straight context and crossed context lists.

On nonsense lists the only cue is of ear of arrival and errors of all kinds are frequent.

It is difficult to compare these results with those of previous experiments which investigated the effect of presentation, or of position because of the different kinds of list used here and the use of a probe rather than recall method. However, some comparisons can be drawn. Broadbent and Gregory (1964) reported that alternation between channels (where channels were either ear of arrival or category words) became easier when more time was available and in a sense this is borne out in the present experiment. There were indeed more correct responses to crossed context lists at slow rates of presentation but this was not so apparent on crossed category lists which were nearer in type to the lists used in Broadbent and Gregory's experiment. It may be that the digit and letter lists which those authors used were more likely to show a rate effect than the lists used in this experiment which were predominantly category names. This suggestion is explored further in experiment 8. Although the experiment was not reported in detail, Broadbent and Gregory (1964) also found evidence that when two phrases were interlaced (ie. crossed context lists) ear by ear recall was impaired rather than that recall by meaning was improved. Again this experiment would support such a conclusion since it is true that there were fewer correct responses to crossed category and crossed context lists than to straight context lists. However such conclusions scarcely do justice to the data found and the importance of looking at all aspects of particular inputs and responses must be emphasised. Theoretical positions which encompass the idea that all inputs are processed to a certain level and that the subject uses all kinds of information to make some kind of sense of the input, again, seem to provide a more coherent framework for these results. The interactions between words in the list, rate and different kinds of semantic content are difficult to explain in terms of different structures, or structural operations such as "pigeon-holing" while the functional models, which more explicitly allow for a build up of evidence, from input, past experience etc can explain the differential effects of context and category by, for instance, the cue evidence referred to earlier, past experience, (MICE EAT CHEESE is presumably a more familiar <u>combination</u> of words than COW PIG DOG), grammatical rules (Subject, Verb,Object as opposed to Noun, Noun, Noun) etc. Neisser's (1967) analysis-by-synthesis or Becker's (1976) verification model of processing have less difficulty in explaining these results than structural models, such as that of Broadbent (1971).

In Neisser's theory, the pre-attentive process picks out parts of the inputs and arrives at preliminary identifications which are then passed on to the second stage of analysis-by-synthesis where different kinds of rules are used to generate a match. Since context is proposed to influence the preliminary analysis these components may be given a high priority, leading to a higher probability that the context cue will be followed rather than the spatial cue. The process of analysis-by-synthesis will use information from the input, knowledge of grammatical rules etc. to actively reconstruct the input. At the slow rate of presentation some rehearsal may occur during presentattion but at the fast presentation rate the subjects are not able to do this. This hypothesis is given support by Bryden's (1962) observation that 14 of his 24 subjects were observed to mumble to themselves at the slow rate of presentation ( 1 dichotic pair per 2 secs) while none did so at the fast rate. (500ms). According to Neisser (1967) subjects must rely more on echoic memory at a fast presentation rate and this may explain the word position effect on crossed context lists. The final word in the list is most likely to be preserved in echoic memory where, as the name suggests, the echo will allow the position of that word to be more accurately identified than one further back in the list. Decisions about the Other word may then be made relative to the decision made about the Critical word. As figure 10 illustrates, if the fourth position word is inaccurately positioned, in the switched position, there is little conflict about the positioning of the Other word since the relative positioning, both in terms of spatial and context cues places it correctly. If the Critical word is placed in the correct position, the positioning of the Other word remains ambiguous because the spatial and context cues are still in conflict. An active functional model, working on probabilities can account for these kind of interactions in a way that structural models do not really approach.

The different kinds of rehearsal proposed by Craik and Lockhart (1972) and by Shiffrin (1976) may also provide an explanation of the discrepancy in the number of switched responses at fast and slow rates of presentation as well as the recency effect. As far as the latter is concerned, the recency effect can be explained by the fact that the final position word occurs closest in time to the probe item in less than two seconds. The sensory or phonemic encoding is therefore less likely to have been superceded by deeper analyses to the semantic level. The cue for spatial location will therefore be predominant and, it can be argued, becomes part of the equation of the deeper analysis of previous words.

If Type I rehearsal (Craik and Lockhart (1972)) which is rehearsal at one level of processing occurs at slow presentation rates at the stimuli arrive, and is a strategy which many subjects adopt, that rehearsal may preclude further encoding (Type II rehearsal) to deeper levels. When overt rehearsal cannot take place because the stimuli are arriving too rapidly, further encoding, to a deeper level of analysis may occur because subjects have to listen in a more passive way. It can therefore be suggested that the semantic cue overrides the spatial cue at the fast presentation rate because the stimuli are encoded to a deeper level with loss of the physical information at an earlier level.

Since encoding to deeper levels of analysis clearly takes more time than encoding to earlier levels, this hypothesis may seem counter-intuitive since there is more time available for processing at the slow rate of presentation than the fast rate of presentation but the control processes that the subjects utilise, such as overt rehearsal can override what may be regarded as an automatic process of encoding outwith the subject's consciousness. This is similar to the argument of Shiffrin and Schneider (1977) who suggested that limitations in divided attention arise from the limited rate of serial operations in controlled processing.

In summary, it is suggested that the effect of rate of presentation on switched responses is due to subjects utilising rehearsal at the slow rate of presentation. This subject controlled processing cannot be carried out at the fast rate of presentation and encoding of the input may progress to a deeper level of analysis where the semantic cue overrides the cue of spatial location. The position effect can be explained by recency where the final word is present in echoic memory (to use Neisser's terminology) or, in Craik and Lockhart's (1971) view, survive on phonemic (and presumably sensory) encoding, which gives rise to good immediate recall. Crossed category lists do not show this semantic effect to the same extent as crossed context lists because they cannot be processed to such a deep level of analysis, and having less weighting in favour of the semantic cue than the crossed context lists.

Finally the complex interaction of variables in this experiment must be emphasised, where the differing semantic content of context and category inputs, often utilised as if they had the same effect; showed different interactions with rate and with word position.

Processing time is clearly an important factor within this formulation and the following experiment was designed to allow more processing time at the response end of processing rather than at input.

STRUCTURAL AND FUNCTIONAL FACTORS

AFFECTING SELECTIVE RESPONSE TO

COMPLEX AUDITORY INPUT

Chapter 6. Immediate and Delayed Recall in Divided and Focused Attention.

**Experiment 6 : Introduction**

The main difference between the previous two experiments and the more usual split span experiments was the use of the position probe, so that the required stimuli were retrieved from memory. The rate of switched responses in experiments 1 and 4 indicated that the two methods were approximately equivalent but in this and the following experiments the ordinary recall method was used since that has been most commonly used in similar experiments and so that different methods of scoring could be investigated.

The final three experiments examine the role of memory in the processing of these dichotic lists by using a delayed recall task. In chapter 1 various proposals regarding memory were reviewed and the structural model of, for instance, Broadbent (1958) were compared with the functional models propounded by, for instance, Neisser (1967), Craik and Lockhart (1972) and Shiffrin (1976). An important component of the latter two is the distinction between maintenance rehearsal and coding rehearsal.

In the previous chapter it was suggested that switched responses occurred less frequently with a slower presentation rate because maintenance rehearsal could be carried out as the lists progressed, while at a faster presentation rate, coding to a deeper level of analysis occurred with material which could be coded to the level of meaning ie. the crossed context lists. In the following two experiments stimuli were presented at a constant rate but processing time was manipulated in order to look further at the possibility of coding rehearsal in divided and focused attention with lists capable of being processed to different levels of meaning.

## Experiment 6

### Method

Twenty subjects were assigned to two different conditions: Immediate Recall or Delayed Recall. In the Immediate Recall condition subjects were given twelve seconds to make their responses and in the Delayed Recall condition there was an interval of eighteen seconds between lists and subjects were not allowed to make their response until six seconds had passed. A metronome with a light which flashed once per second was placed in front of the subjects in the Delayed Recall group and they were asked to count six flashes after the end of each list, before responding. The experimenter observed the subjects to make sure that this condition was adhered to.

### Stimulus Material

Twenty different examples of five different List types were presented. Each List consisted of three dichotic word pairs. The five List types were as follows: (1) Straight Context : a phrase presented to each ear, (2) Crossed Context : a phrase presented to each ear but with the middle words crossed, (3) Crossed Category : six words belonging to the different categories; the middle words crossed, as in Crossed Context, (4) Disordered Context : two phrases which had been re-arranged presented to each ear (as in experiment 2), (5) Nonsense : six unassociated words. The categories used in compiling the crossed category lists were the same as those used in experiment 5.

All subjects were asked to write down under the headings Right and Left what they had heard in each ear, in the order that they heard the items.

## Results

### Section 1

In section 1 of the results, three way analyses of variance were carried out on the different response types of omissions, correct responses, switched responses and position errors. The ANOVA design was of Recall (between subject) x List x Position (within subject factors). The straight context lists were omitted from the analysis of switched responses because there were so few responses of that kind. Individual comparisons were carried out using the Scheffe test. The results of these analyses in terms of significant effects are shown in Tables 28 and ANOVA summary tables are given in Appendices 3.1 to 3.4. Refer to these appendices for specific F values and probability levels.

1. Immediate and Delayed Recall

The main effect of Recall was significant only on switched responses $F(1,18) = 10.48$ $p < .01$. Omissions, correct responses and position errors showed no such main effect. However, different responses depended on interactions with both list type and position. Figures 11 to 14 show the data for the different response types. Individual comparisons suggest that there were significantly more switched responses to second position words on crossed context lists on the Delayed Recall condition than the Immediate Recall condition. No such significant difference occurred on crossed category lists, though reference to Figure 13 shows that the two lists showed similar patterns of switched responses as compared with the other list types. There was also a significant difference found between Immediate and Delayed recall on disordered context lists, with more errors of position in the Delayed condition. This difference was not found on other lists.

Figures 11 and 12 show the differential effects of Delayed Recall on omissions

Table 28: Significant main and interaction effects in 3-way ANOVAs for each condition and response type

| | Omissions | Correct | Switched | Position Errors |
|---|---|---|---|---|
| Recall | | | ** | |
| List | ** | ** | ** | ** |
| Position | ** | ** | ** | ** |
| Recall x List | * | * | | ** |
| Recall x Position | | * | * | |
| List x Position | ** | ** | ** | |
| Recall x List x Position | ** | ** | ** | |

$* = p < .05$

$** = p < .01$

Figure 11: Mean number of omissions at each position with immediate and delayed recall

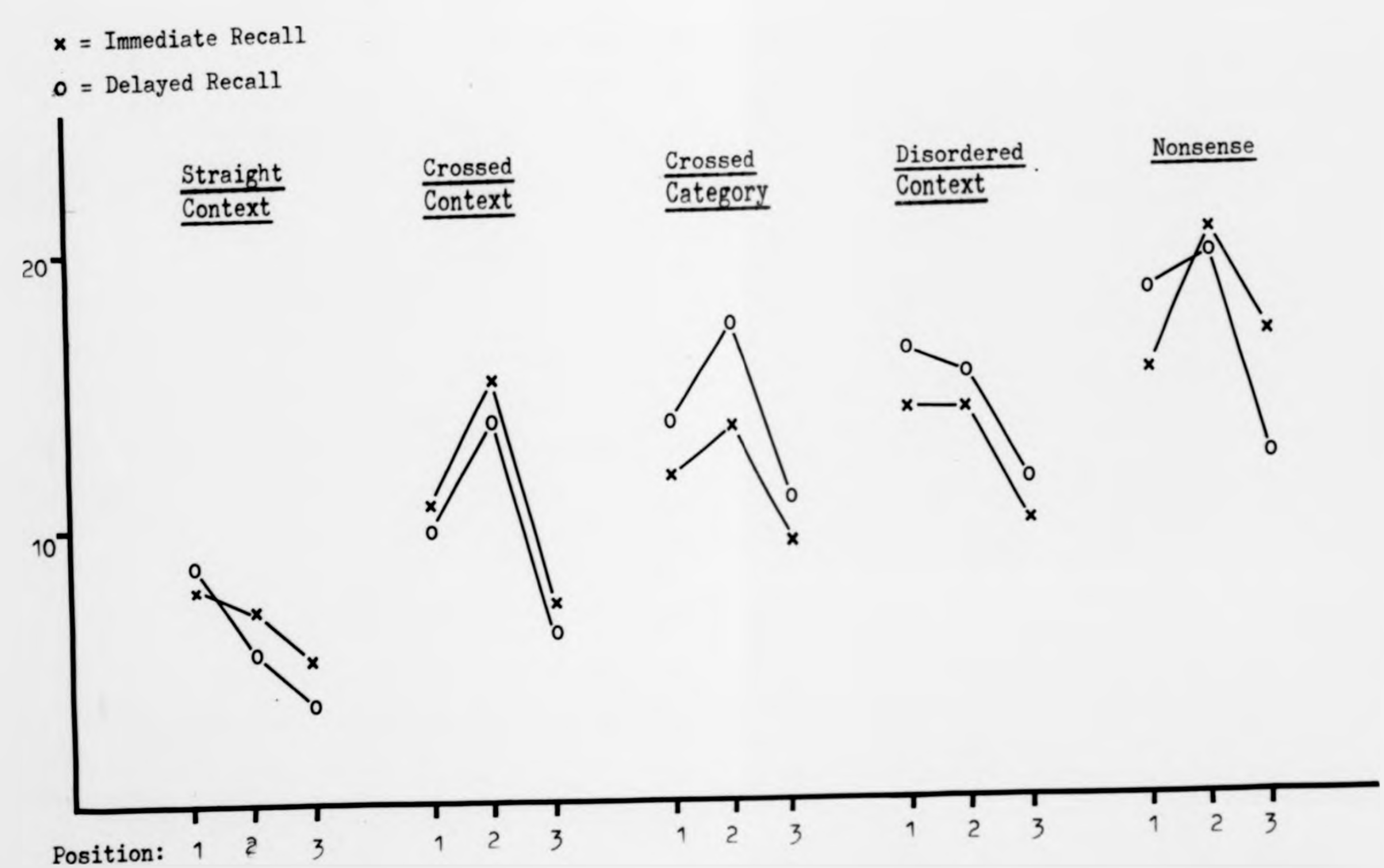


Figure 12: Mean number of correct responses at each position with immediate and delayed recall

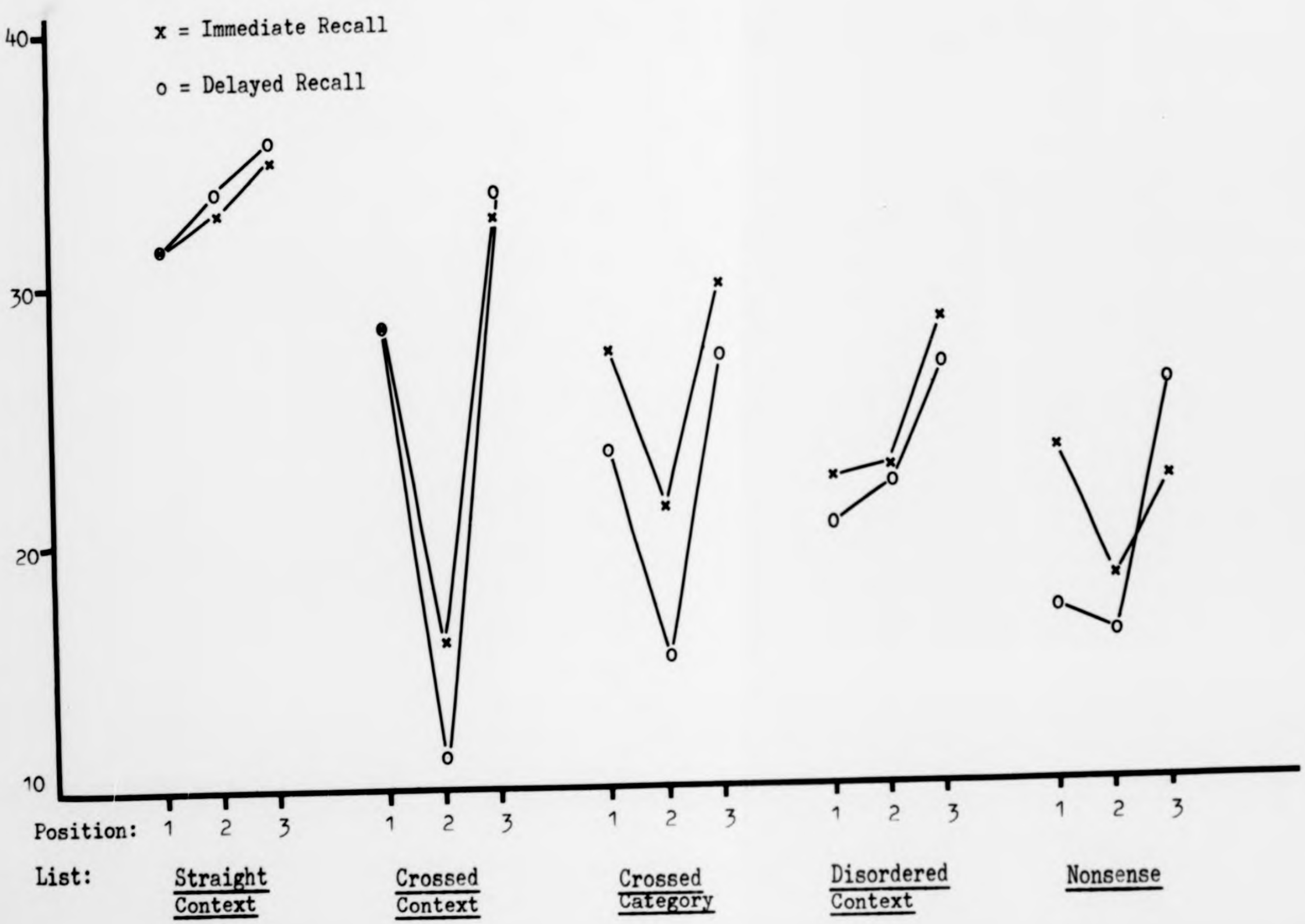


Figure 13: Mean number of switched responses at each position with immediate and delayed recall

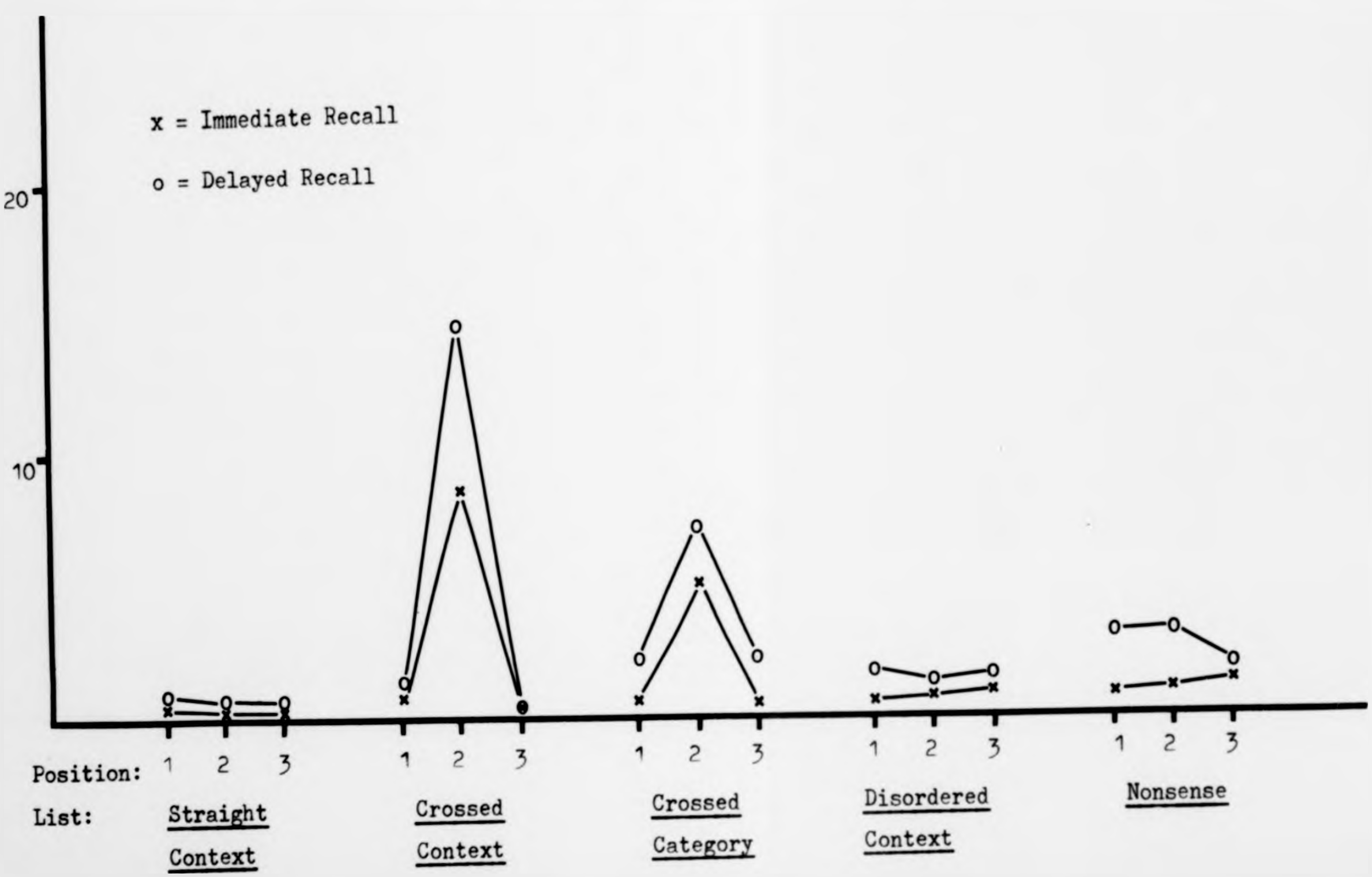
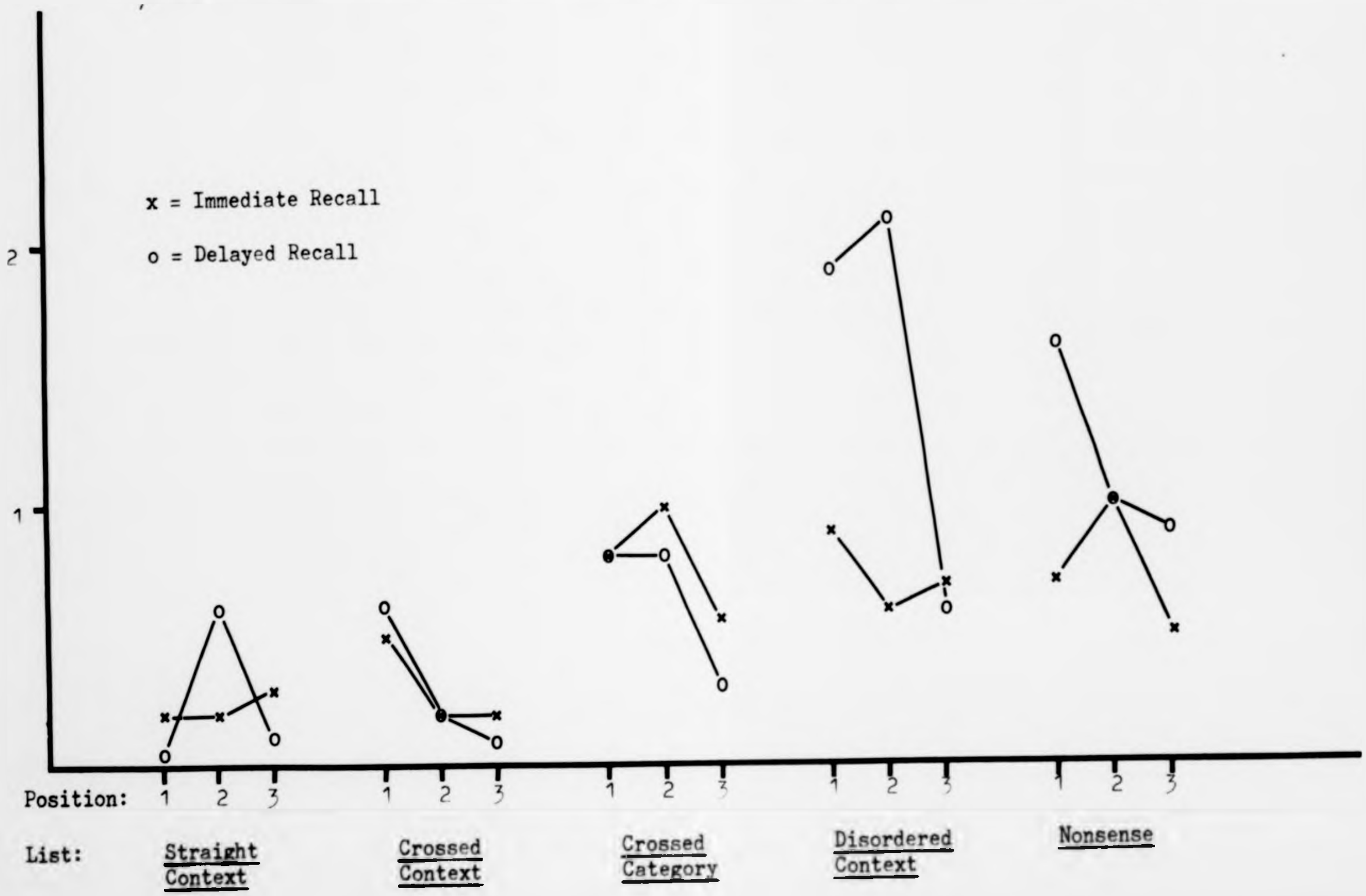


Figure 14: Mean number of position errors at each position with immediate and delayed recall



and correct responses to different list types, both of which showed three way interactions between recall condition, list and position.

2. List types

Differences between lists on omissions almost exactly mirrored differences on correct responses, as might be expected. There were, however, significantly more omissions on disordered context lists than on crossed context lists, while correct responses did not differ significantly. This result was also found in experiment 2. As the amount of semantic constraint decreases, from straight context to nonsense lists, omissions show an increase and correct responses decrease. Comparisons between omissions and correct responses on all lists, using the Scheffe test are shown in Tables 29 and 30.

Comparisons between crossed context and crossed category lists on different response types revealed no significant differences on omissions correct responses or position errors. Differences on switched responses were found on second position words, depending on the Recall condition. There were significantly more switched responses to crossed context lists than crossed category lists in the Delayed Recall condition but the two lists did not differ in the Immediate Recall condition. Crossed category lists and crossed context lists did not differ significantly on position errors.

3. Position effects

Without reference to the other variables, there are significantly more correct responses made on position three than on other positions. Switched responses occur on second position words on both crossed context and crossed category lists more frequently than on the other two positions. Omissions also occurred significantly more often on position two on crossed context, category and nonsense lists. Only position errors showed no interaction effects between position and

Table 29: Comparisons made between lists for each recall condition

: Omissions

IMMEDIATE RECALL

| | Mean | Cro.Co. | Cro.Ca. | Dis.Co. | Nons. |
|---|---|---|---|---|---|
| Straight Context | 20.2 | * | * | * | * |
| Crossed Context | 32.8 | | NS | NS | * |
| Crossed Category | 34.1 | | | NS | * |
| Disordered Context | 39.4 | | | | * |
| Nonsense | 52.1 | | | | |

DELAYED RECALL

| | Mean | Cro.Co. | Cro.Ca. | Dis.Co. | Nons. |
|---|---|---|---|---|---|
| Straight Context | 17.2 | * | * | * | * |
| Crossed Context | 30.0 | | NS | * | * |
| Crossed Category | 41.8 | | | NS | NS |
| Disordered Context | 42.9 | | | | NS |
| Nonsense | 50.1 | | | | |

* = $p < .05$

NS = No Significant Difference

Table 30: Comparisons made between lists for each recall condition

: Correct Responses

IMMEDIATE RECALL

| | Mean | Cro.Co. | Cro.Ca. | Dis.Co. | Nons. |
|---|---|---|---|---|---|
| Straight Context | 98.6 | * | * | * | * |
| Crossed Context | 76.6 | | NS | NS | * |
| Crossed Category | 77.1 | | | NS | * |
| Disordered Context | 76.3 | | | | * |
| Nonsense | 62.9 | | | | |

DELAYED RECALL

| | Mean | Cro.Co. | Cro.Ca. | Dis.Co. | Nons. |
|---|---|---|---|---|---|
| Straight Context | 100.7 | * | * | * | * |
| Crossed Context | 73.1 | | NS | NS | * |
| Crossed Category | 64.8 | | | NS | NS |
| Disordered Context | 68.4 | | | | NS |
| Nonsense | 58.3 | | | | |

* = $p < .05$

NS = No Significant Difference

the other two variables.

Section 2

The number of lists from which all six words had been correctly recalled, regardless of position, were identified. These are shown in Table 31 along with the errors in position which were made.

Table 31 : Mean percentage of lists from which all 6 words had been recalled (a) in the correct positions (b) with the second position words switched and (c) in some other position.

| Lists | Recall | Correct | Switched | Other | Total |
|---|---|---|---|---|---|
| Straight Context | Immediate | 28.5 | 0 | 0.25 | 28.75 |
| | Delayed | 30.25 | 0.25 | 0.25 | 30.75 |
| Crossed Context | Immediate | 4.25 | 5.75 | 0 | 10.00 |
| | Delayed | 3.25 | 12.75 | 0 | 16 |
| Crossed Category | Immediate | 8.25 | 1.5 | 0.25 | 10.00 |
| | Delayed | 5.25 | 2.75 | 0.5 | 8.5 |
| Disordered Context | Immediate | 8.25 | 0 | 1.25 | 9.5 |
| | Delayed | 8.00 | 0 | 2.00 | 10.00 |
| Nonsense | Immediate | 2 | 0 | 0 | 2 |
| | Delayed | 2.25 | 0.25 | 0.75 | 3.25 |

As one would expect from the omission data given (see Figure 11) there are most correct lists on Straight Context and fewest on Nonsense. Of greater interest is the discrepancy between the Crossed Context and Crossed Category lists. The data for correct and switched responses were analysed using a 2 x 2 x 2 ANOVA, (Recall x List type x Correct or Switched response). The ANOVA summary table is given in Appendix 3.5 and shows a significant difference between the number of crossed context and crossed category lists (Total column in Table 31) and significant interactions between Recall and List $F(1,18) = 5.65$ $p < .05$ and between Recall and Response $F(1,18) = 13.03$ $p < .01$. These results reflect the fact that there are significantly more Crossed Context than Crossed Category lists which show the switched positions in the Delayed condition, but not in the Immediate condition, and, over both List types, that there are more correct responses in the Immediate condition and more switched responses in the Delayed condition.

Discussion

In experiment 5 it was found that there were complex interactions between the variable of presentation rate and the structural components of the lists. Table 28 showed the different interactions found, depending on the response type measured, and it illustrates the difficulty of making general interpretations about the effect of stimulus content, when that content is poorly controlled. It seems that almost any variable investigated will have some effect on the recall of the material.

In this experiment the delay task was designed so that it would not interfere with the items in short-term memory and the results indicate that the major effect of that delay was in the re-organisation of items on crossed context and disordered context lists; particularly on the former. This did not occur on crossed category lists to the same extent, but, once again, the results are not unequivocal. Crossed context lists had significantly more switched responses than crossed category lists only in the Delayed condition and this was found both under item analysis and "whole list" analysis.

Using the second method of analysis it is perhaps clearer that delayed recall increased accuracy (in terms of items identified) in crossed context list while it did not do so on crossed category lists. There is a slight but insignificant increase in recall by category in the delayed condition but a drop in the total number of lists recalled. All the other lists showed a slight increase. Although not statistically significant, these results are also apparent in the item analysis. For instance, there is no significant difference between omissions in the two recall conditions for each list. However, the relationship between crossed context, and the other lists changes depending on Immediate and Delayed recall. Crossed context and nonsense lists show a slight reduction in omissions in Delayed recall in comparison with Immediate recall while crossed category lists and disordered context lists show some increase. Similarly, with correct responses, the relationships between crossed category, disordered context and nonsense lists change depending on recall condition. All three list types have fewer correct responses in the Delayed than the Immediate condition, but this is least for nonsense lists (over all three positions) most for crossed category lists with disordered context lists in an intermediate position. This might suggest that the association between items on crossed category lists is not only less helpful than on crossed context lists, but actively more damaging than the unassociated words in nonsense lists when recall is delayed. As discussed in Chapter 5: crossed category lists have less structure than crossed context lists and more, but conflicting structure, than nonsense lists. Both from the previous experiment and this one crossed category lists are better recalled than nonsense lists suggesting that category names do aid immediate recall. These categories are relatively less helpful when they have to be held in store for even a few seconds. There is no reason to believe that the information simply decays and is lost, since in that case there would be no reason for the crossed category lists to show a higher rate of omissions on delayed recall relative to the increase of omissions on nonsense lists. It may therefore be that the category names interfere with each other during the Delay period. Unfortunately there is another possible interpretation in terms of the delay task. Since some of the crossed category lists contained numbers, it could be that the counting of six metronome flashes interfered with the processing of some of those lists. In experiment 8, a different kind of delay task was utilised, together with different types of associated items.

Leaving aside the possibility mentioned above, it is clear that context has a more powerful effect than category. This is also seen in disordered context lists where within ear errors exceeded between ear errors. The tendency to re-order into context is clearly much less on disordered context than on crossed context, suggesting that temporal tags are less likely to be "lost" than channel tags. This is in accord with the views of Mewhort (1972) and Penney (1976) who used different experimental paradigms but also concluded that the temporal tags were more salient than the tags for ear of arrival.

The effect of delay can be viewed in terms of continued coding of the input. It seems unlikely that this process is one of active rehearsal with a process of re-ordering the items in order to aid maintenance rehearsal. A conscious decision to do so, on the part of the subject is unlikely to be forgotten within the space of six seconds. For instance, if it was a conscious process the subject would be saying to himself - "I heard Mice Black Cheese in one ear and Big Eat Dog in the other, but I will recall them better if I rehearse Mice Eat Cheese and Big Black Dog". Between making that decision and writing the response, the subject would have to forget that self-instruction in order to produce the switched response. Shiffrin's (1976) conception of coding rehearsal or Neisser's (1967) active verbal memory provide a framework within which other items in the list,context and general knowledge in long-term memory are related to each input as it is "dumped" into short-term memory. Coding rehearsal or the processes of active verbal memory then lead to the storage of semantic features which improve recall, as is indeed found with crossed context lists, and to a lesser extent with disordered context lists in the present experiment.

The proposed difference between maintenance rehearsal and coding rehearsal explains why giving more time at input (slow presentation rate) results in fewer switched responses while giving more time at the response end results in an increased number of switched responses. At the slow rate of presentation subjects can utilise maintenance rehearsal as the lists progress, thereby reinforcing the physical cues. At faster rates of presentation, only coding rehearsal occurs and as more time is available with delayed recall, the higher level features of the words, ie. semantic features are embellished while the lower level features are discarded. Rehearsal at slow rates could therefore be regarded as predominantly a control process and at fast rates as predominantly an automatic process.

Shiffrin and Schneider's (1977) conclusions regarding divided attention cannot be straightforwardly applied to these experiments since they are mainly concerned with detection tasks. They conclude their discussion of attention literature by suggesting the following rules:

1. Divided attention deficits arise from limitations on controlled processing.
2. Dividing attention is possible when the targets have been consistently mapped during training until automatic detection operates.

As regards the first rule, whether or not it applies is related to whether or not a switched response is regarded as a deficit. In terms of the accurate recall of what was presented, it is, and the suggestion that controlled processing is more operative at slow rates of presentation, but not perhaps at fast rates lends weight to this argument. The consistent mapping in rule 2 can be seen as subjects carrying out the very highly practised task of listening to contextual speech. If one considers that that is a task in which automatic processes operate, with the characteristics that they are not hindered by capacity limitations of short-term memory, once initiated they are difficult to stop, they are difficult to modify and will usually be unconscious, there is a framework for the inability to ignore contextual cues in a way that is apparently carried out unconsciously.

Shiffrin and Scheider (1977) also suggest rules governing focused attention.

1. Focused attention deficits arise when distracting stimuli initiate automatic attention responses.

2. Focusing attention is possible during controlled processing.

The first of these is examined in the following experiment which presented the same material as that used in experiment six but required focused attention rather than divided attention.

## Experiment 7

### Method

The experimental design was identical to that of experiment six except in the instructions to subjects. Sixteen subjects participated, eight being randomly assigned to either the Immediate or Delayed condition. Subjects were asked to attend to the items presented to one ear and ignore the other, and to respond by writing down what they had heard in the attended ear. The delayed recall task of counting metronome flashes was the same as that used in experiment six.

### Results

As one would expect there was a low error rate in comparison with previous experiments. Only correct responses and omissions were analysed, and the whole list method was utilised, so that the scores represent the number of lists which contained an omission. On neither correct responses nor omissions was any significant effect of Recall condition found. There was a significant effect of List type on both, $F(4,56) = 11.39$ $p < .01$ for correct responses and $F(4,56) = 7.56$ $p < .01$ for omissions. Scheffe tests showed that straight context and nonsense lists had significantly more correct responses and fewer omissions than crossed context and crossed category lists, with disordered context lists in an intermediate position. ANOVA summary tables are given in Appendices 3.6 and 3.7. Table 32 gives the mean number of lists of each type.

The number of switched responses and position errors is too small to subject to an analysis of variance, however, it would appear that there is an increase in switched responses on position two of the crossed context lists. Once again, there is a slight but clearly non-significant increase in switched responses to crossed category lists, as there is with position errors on disordered context.

Table 32: Mean number of lists (a) containing an omission, in which all three words were identified (b) in the correct positions, (c) with the second word switched, (d) with the first or third words switched and (e) with a position error.

IMMEDIATE RECALL

| | Straight Context | Crossed Context | Crossed Category | Disordered Context | Nonsense |
|---|---|---|---|---|---|
| Omissions | 0.75 | 2.5 | 3.75 | 2.38 | 0.88 |
| Correct | 19 | 17.25 | 15.38 | 17.38 | 18.75 |
| Switched (2) | 0.25 | 0.25 | 0.38 | 0.13 | 0.25 |
| Switched (1 or 3) | 0 | 0 | 0.25 | 0.13 | 0 |
| Position Errors | 0 | 0 | 0.25 | 0 | 0.13 |

DELAYED RECALL

| | Straight Context | Crossed Context | Crossed Category | Disordered Context | Nonsense |
|---|---|---|---|---|---|
| Omissions | 1 | 2.63 | 2 | 1.5 | 0.88 |
| Correct | 19 | 15.63 | 16.63 | 17.75 | 19 |
| Switched (2) | 0 | 1.5 | 0.5 | 0.25 | 0 |
| Switched (1 or 3) | 0 | 0.25 | 0.63 | 0.13 | 0.13 |
| Position Errors | 0 | 0 | 0.25 | 0.38 | 0 |

Discussion

It seems that focused attention is more difficult on lists which have confounded physical and semantic cues, as regards omissions and correct responses. Neither response type showed differences between straight context and nonsense lists, while both differed from crossed context and crossed category lists. Since performance was near ceiling level on the former two lists it may be that differences between them could not be detected. It appears then, that interference was greatest on crossed context lists, followed by the crossed category lists and disordered context lists. However, in contrast to experiment six, delayed recall appeared to aid the correct recall of crossed category lists, but not that of crossed context lists, in terms of the number of lists showing omissions.

Although, the small number of errors makes analysis difficult it would seem that the delay in focused attention gives rise to more interference in terms of switched responses and omissions in crossed context lists, and less, at least on omissions, in crossed category lists. Although by no means conclusive, this lends some weight to the hypothesis that context may initiate automatic attention responses while categories do not. Nevertheless it is clear that subjects can exert considerable control over the attention process and the implications for "filtering" in Broadbent's theory are discussed in the final chapter.

# STRUCTURAL AND FUNCTIONAL FACTORS AFFECTING SELECTIVE RESPONSE TO COMPLEX AUDITORY INPUT

## Chapter 7. Priming Effects and Delayed Recall of Crossed Lists of Differing Semantic Complexity.

Experiment 8 : Introduction

The final experiment was originally designed to follow up the finding, in experiment 2 that there was a small reduction in the number of switched responses to crossed context lists when disordered context lists were presented in conjunction with them rather than straight context lists. The opportunity was also taken to investigate further the effect of different degrees of association between items and the delay task.

Experiment 2 was presented as investigating the effects of expectation on switched responses. As was pointed out, subjects' entire experience would lead them to expect words to follow in context and the presentation of disordered context lists rather than straight context lists was an attempt to change their immediate experience and expectations.

The effect of expectations, context and word probability are clearly closely related. If we take Treisman's (1960) shadowing experiment as an example, the effects of each can be demonstrated. In that experiment,subjects shadowing one ear,briefly switched over to the other when the context changed from the attended ear to the unattended ear. This occurred significantly more often when the shadowed message was an extract from a novel than when it consisted of second order or eighth order approximations to English. Treisman interpreted these results in terms of the attenuating filter model where the transition probabilities lower the thresholds of units which are probable in the context just heard. This may be a complicated way of saying that we hear what we expect to hear, not necessarily what is presented. Warren and Warren (1970) have shown the effect of context in what they call the phonemic restoration effect. They presented sentences in which a phoneme was deleted. For instance when "it was found that the ....... eel was on the ......", was presented, what was heard depended on the content of the final word. If "shoe" was given the earlier word was perceived as "heel", if "axle" was presented last, then "eel" became "wheel". If no final word was presented, "eel" was accurately perceived.

It is also certainly the case that it is easier to recognise words if they follow one another grammatically. Miller (1962) presented simple sentences in noise for identification. When the same sentences were presented backwards recognition of the words was much poorer than in the straight order and this is, of course, what was found in experiments 2 and 6 where disordered context lists are less well recalled than straight context lists. Subjects are better able to perceive words in grammatical order because of their knowledge of grammatical rules.

The word frequency effect, that words which are common in the language are more easily perceived than rare words appears to differ from the effect of context. The experiments of Broadbent (1967), Broadbent and Broadbent (1975) and Morton (1968, 1970) indicate that the high frequency of certain words in our past experience lead to a bias towards those words so that we need less information in order to perceive them. It has been shown that this effect is not due to the probability of the letters within the word. Broadbent and Gregory (1971) presented words of the same probability but constructed of more or less probable letters. Perception of the words with more probable letters was no better than those with less probable letters.

If a new vocabulary of words is given to subjects to work from the effects of probability continue to operate. Goldiamond and Hawkins (1958) used nonsense words which had been presented more or less often in an experiment. These were presented tachistoscopically in a second experiment but where the "correct" word was never actually presented and subjects received a flash of light. A word (or in this case, nonsense syllable) frequency effect was found even though no stimulus was presented.

The effects of priming are also relevant to this discussion of response bias. In a lexical decision task Meyer and Schvaneveldt (1971) presented two strings of letter and subjects were required to respond positively if both strings of letters were words and negatively if they were not. Responses were faster when the two sets were words which were related to each other semantically than if they were unrelated.

Overall it has been shown that the frequency of a word in the language affects the probability of whether or not a word is perceived and this applies to "new languages", such as nonsense syllables.

Context may refer not only to verbal context but also to situational context. For instance, sitting at the dinner table at the beginning of a meal the probability of hearing "salt" following "Pass me the ......" is much higher than the word "port". At the end of the meal "port" may be more probable.

The number of words previously heard may also effect the probability of perceiving a word and the individual's general knowledge may also be of importance For most, the probability of hearing the word "deck" following "The boy stood on the burning ....." is higher than when we hear "he fell to the .....". Taken in isolation "floor" or "ground" are as or more probable than "deck" in the latter case. However, if the context is longer, for instance in "the ship lurched as a sudden wave caught it and he fell to the .....","deck" then becomes more probable than the word "ground".

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So perception of any one word may depend on word frequency, verbal context, situational context, length of utterance and semantic redundancy. These can be seen as altering response bias, in the same way that instructions to subjects may do. If subjects are told in advance what they are going to hear, they may use different recall strategies than if they are not so informed (Gray and Wedderburn, 1960).

Three different models of response bias may be distinguished: active, passive and interactive. An active model suggests that a subject actively seeks for information to confirm his bias. An alternative view is that it is a passive process, in which bias lowers the amount of evidence needed to produce perception of a particular word. Treisman's (1960) filter attenuation model can be described as such, as can Broadbent's theory (1971).

The interactive or 'verification' model proposed by Becker (1976) is similar to that of Neisser (1967) in that there are two stages in the process. In a first passive stage, partial analysis of stimuli leads to certain possibilities which can then be more actively tested in the second stage. In the case of context a word may be primed in such a way that the passive stage requires little evidence before the active verification stage commences.

The finding that switched responses to crossed context lists was slightly less frequent when disordered context lists were presented in experiment 2 can be considered both in terms of the effect of context and of priming. In general, experiments on priming have shown that word processing can be facilitated or show interference from associated words. Some studies showing this were reviewed in chapter 1.

The difference in switching noted in experiment 2 suggested a different kind of priming, where the perception of the messages depends on the structure of preceding messages in terms of its contextual content. In the following experiment lists of crossed context and two different kinds of crossed category were associated with either straight context or straight category lists and compared with lists which were presented with nonsense lists.

## Experiment 8

### Method

Forty subjects were tested. They were divided at random into four groups of ten subjects.

### Stimulus Lists

30 lists of three different types were constructed; Crossed Context lists, as in previous experiments, Easy Crossed Category lists which consisted of three digits and three letters, with the middle items crossed and Difficult Crossed Category lists. In the latter three words from one category were crossed with three words from a different category. The categories included animals, parts of the body, trees, colours, fish and names. All words were monosyllabic. Subjects in all four groups were presented with these lists, examples of which are given in Table 33.

30 further lists of 3 types designed as 'Prime' lists were constructed. Crossed Context Prime lists were Straight Context lists, Easy Crossed Category Prime lists consisted of three digits presented to one ear and three letters to the other, and the Difficult Primes similarily consisted of words from two different categories, each category presented to one ear.

The 60 lists of the six types were arranged in such an order that Crossed Context lists were always immediately preceded by either other Crossed Context lists or by Crossed Context Prime lists. Easy and Difficult lists were arranged in similar order with their Primes. Two of the groups of ten subjects were presented with these lists in a 'Straight Prime' condition. (See Table 33). The other two groups of subjects were presented with the same Crossed Context, Easy and Difficult lists but these were arranged with Nonsense Primes. (See Table 33). These were roughly based on their counterparts in the Straight Prime condition

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30 lists of three different types were constructed; Crossed Context lists, as in previous experiments, Easy Crossed Category lists which consisted of three digits and three letters, with the middle items crossed and Difficult Crossed Category lists. In the latter three words from one category were crossed with three words from a different category. The categories included animals, parts of the body, trees, colours, fish and names. All words were monosyllabic. Subjects in all four groups were presented with these lists, examples of which are given in Table 33.

30 further lists of 3 types designed as 'Prime' lists were constructed. Crossed Context Prime lists were Straight Context lists, Easy Crossed Category Prime lists consisted of three digits presented to one ear and three letters to the other, and the Difficult Primes similarily consisted of words from two different categories, each category presented to one ear.

The 60 lists of the six types were arranged in such an order that Crossed Context lists were always immediately preceded by either other Crossed Context lists or by Crossed Context Prime lists. Easy and Difficult lists were arranged in similar order with their Primes. Two of the groups of ten subjects were presented with these lists in a 'Straight Prime' condition. (See Table 33). The other two groups of subjects were presented with the same Crossed Context, Easy and Difficult lists but these were arranged with Nonsense Primes. (See Table 33). These were roughly based on their counterparts in the Straight Prime condition

Table 33: Examples of stimulus lists used in experiment 8.

| Crossed Context | | Easy Crossed Category | | Difficult Crossed Category | |
|---|---|---|---|---|---|
| Poor | Time | K | 2 | Cow | White |
| For | Old | 6 | D | Green | Pig |
| Man | Tea | S | 9 | Sheep | Red |
| **Straight Prime** | | **Straight Prime** | | **Straight Prime** | |
| King | Cold | B | 4 | Oak | Leg |
| And | As | M | 8 | Ash | Arm |
| Queen | Ice | T | 5 | Pine | Hand |
| **Nonsense Prime** | | **Nonsense Prime** | | **Nonsense Prime** | |
| Sing | Bold | Bee | Door | Most | Leg |
| Band | Has | Them | Late | Crash | Farm |
| Queen | Mice | Tree | Five | Pine | Band |

so that many had identical words in some positions and similar words not belonging to any category appeared in other positions so that all lists consisted of six unassociated words which bore some resemblance to the Straight Prime lists.

One group in each Prime condition was required to respond immediately at the end of each list and the other group after a delay of six seconds, by writing down the six words in the positions that they had heard them on prepared response sheets. The method of delay differed from that used in the previous experiments. A warning tone was sounded six seconds after the end of each list, after which the subjects responded. In the six second period between the end of the list and the warning tone the subjects were asked to join up random dots which were printed on separate sheets. The subjects were told that the aim of this exercise was to join up as many dots as possible in the delay period.

All subjects were given 12 seconds to make their responses. The design of the experiment was therefore a 2 (Immediate or Delayed Recall) x 2 (Straight or Nonsense Prime) x 3 (list type) factor design with the first two between subject and list type a within subject factor.

Results

Section 1

Analyses were carried out on responses to the words in position 2 in the crossed context, easy crossed category and difficult crossed category lists. Separate analyses of variance were carried out on omissions, correct responses and switched responses. Table 34 gives the mean percentage of different responses.

1. Omissions

Significant effects of list type and interactions between List and Prime $F\ (2,72) = 3.95\ p<.05$ and List and Recall $F\ (2,72) = 6.44\ p<.01$ were found. The ANOVA summary table is given in Appendix 4.1. Overall there were significantl; more omissions on difficult lists than the other two list types. (Scheffe test). No significant differences were found between Immediate and Delayed recall or between Straight and Nonsense primes, on each list separately. Figures 15 and 16 illustrate the interactions found.

Table 34 : Percentage of responses to each list within each Recall and Prime condition.

IMMEDIATE RECALL

| | Straight Prime | | | Nonsense Prime | | |
|---|---|---|---|---|---|---|
| | Crossed Context | Easy | Difficult | Crossed Context | Easy | Difficul |
| Omissions | 31.5 | 22 | 50 | 37 | 24 | 51 |
| Correct | 26.5 | 67 | 36.5 | 38 | 64 | 36.5 |
| Switched | 41.5 | 6.5 | 12.0 | 23.5 | 7.5 | 7.5 |
| Other | 0.5 | 4.5 | 1.5 | 1.5 | 4.5 | 5 |

DELAYED RECALL

| | Crossed Context | Easy | Difficult | Crossed Context | Easy | Difficul |
|---|---|---|---|---|---|---|
| Omissions | 23 | 33.5 | 50 | 31.5 | 26 | 43.5 |
| Correct | 18 | 46 | 24.5 | 26 | 51.5 | 34 |
| Switched | 58.5 | 16.5 | 22.5 | 39.5 | 17 | 15.5 |
| Other | 0.5 | 4 | 3 | 3 | 5.5 | 7 |

**Figure 15: Mean number of omissions: List x Recall Interaction**

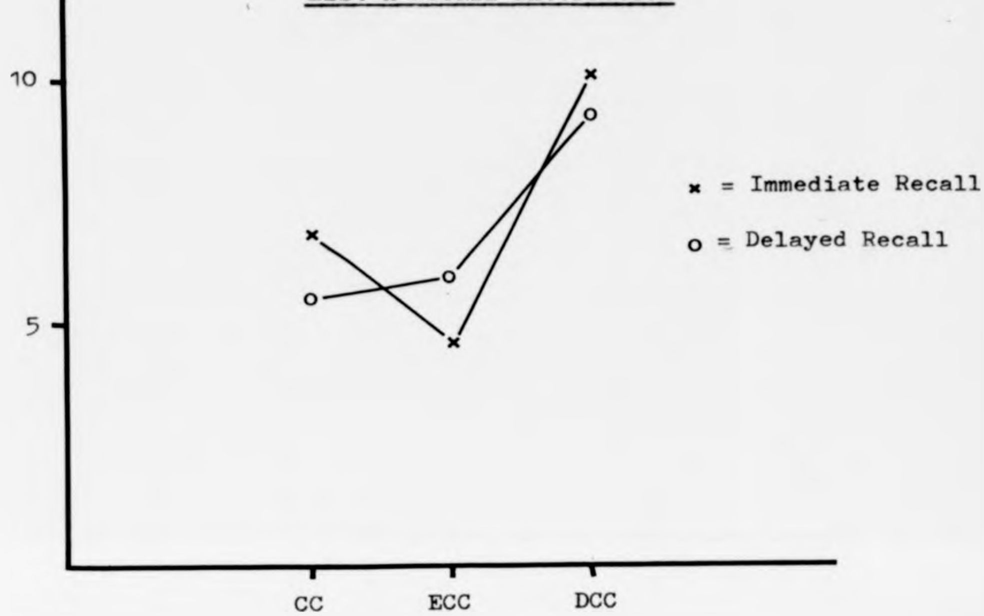
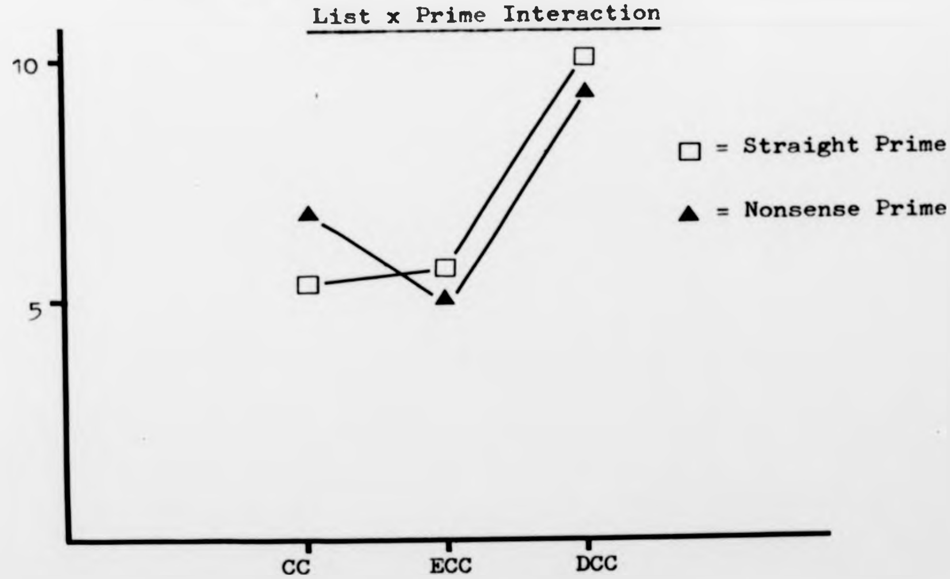



**Figure 16: Mean number of omissions List x Prime Interaction**




CC = Crossed Context

DCC = Difficult Crossed Category

ECC = Easy Crossed Category

Figure 17: Mean number of correct responses on immediate and delayed conditions

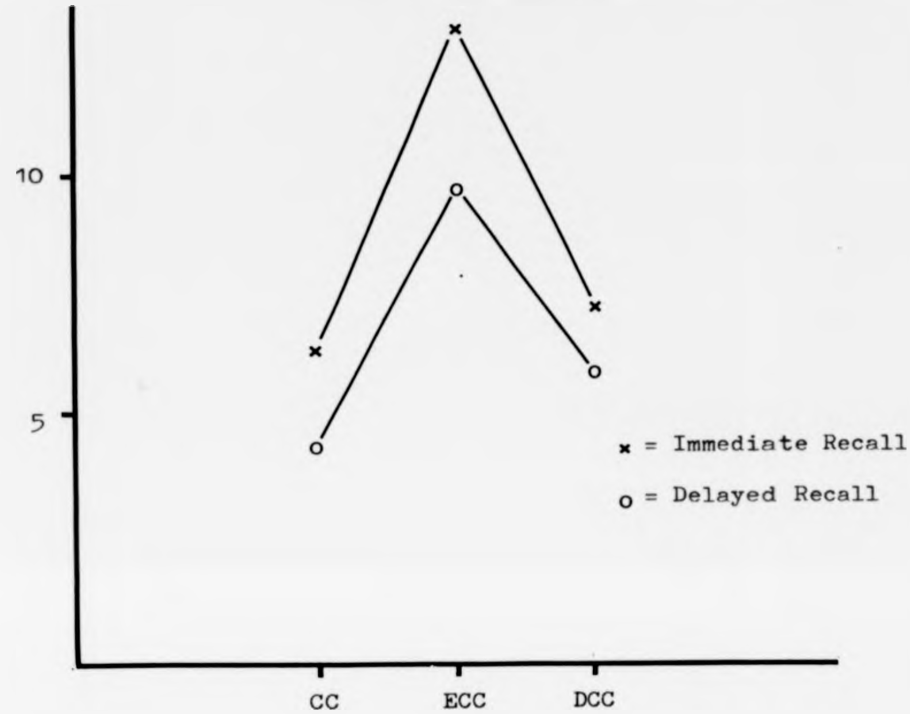
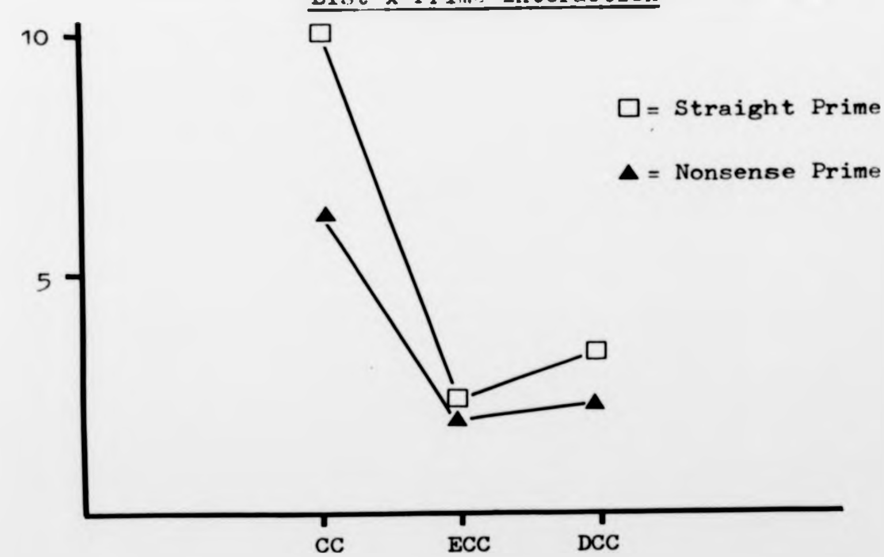



Figure 18: Mean number of switched responses: List x Prime Interaction



2. Correct Responses

Significant effects of Recall $F\ (1,36) = 8.12\ p < .01$ and of List type $F\ (2,72) = 53.94\ p < .01$ were found. No other effects reached the required significance level. (See Appendix 4.2). Figure 17 shows these mean scores. Over all list types there were more correct responses on the Immediate condition than the Delayed condition. The easy lists had significantly more correct responses than the other two list types.

3. Switched Responses

The results of the ANOVA (Appendix 4.3) showed significant main effects of Prime, List type and Recall $F\ (1,36) = 14.41\ p < .01$. A significant List x Prime interaction was also found $F\ (2,72) = 6.53\ p < .01$. This interaction is shown in Figure 18. Crossed context lists show a significant effect of Prime while the other lists do not. Over the three list types, there are significantly more switched responses in the Delayed condition than the Immediate condition.

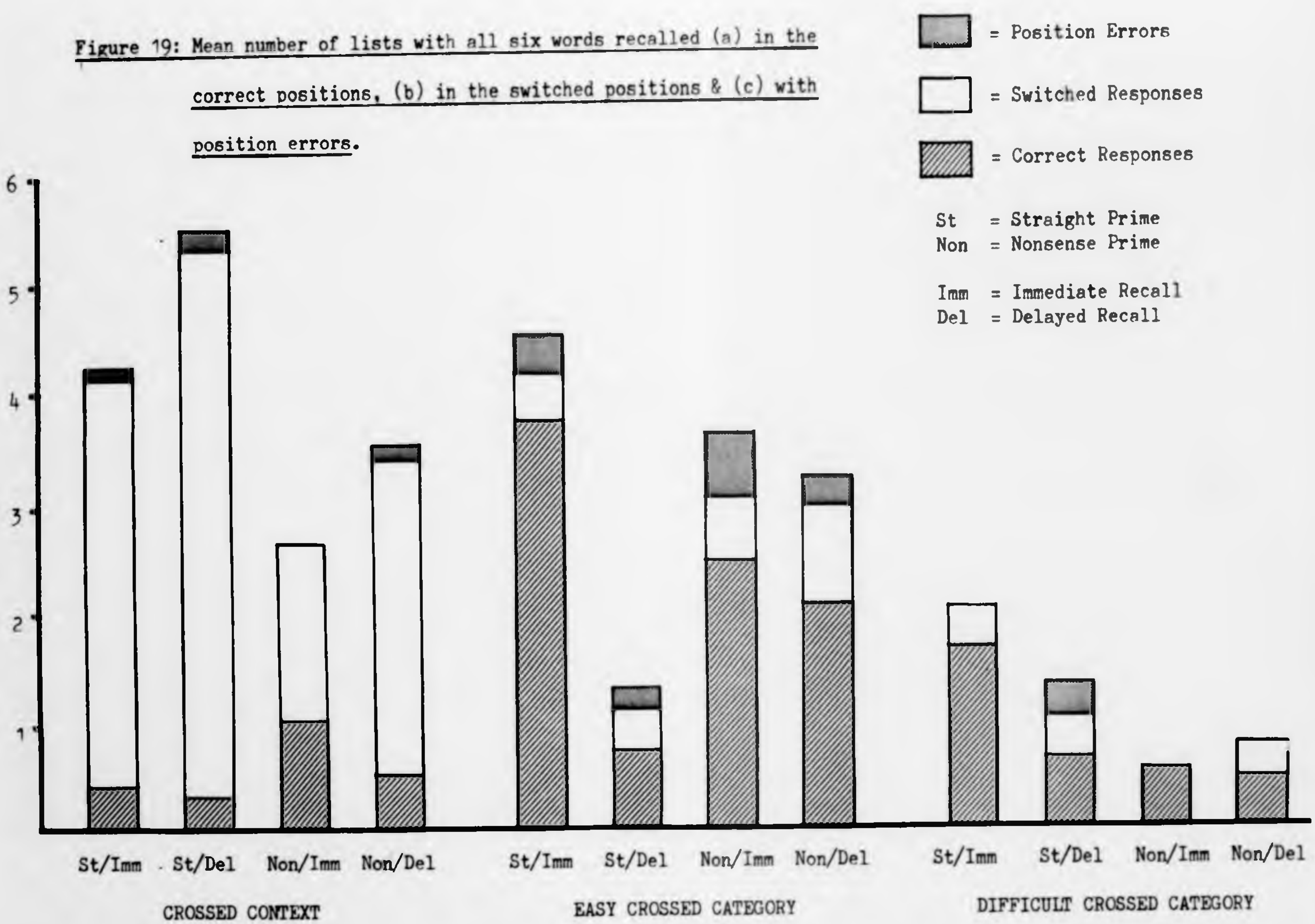
Section 2

Lists from which all six items had been correctly identified were also analysed. Figure 19 illustrates these data.

1. Total number of lists

The ANOVA summary table is given in Appendix 4.4. A significant main effect of List and significant interactions between List and Recall and List and Prime were found, $F\ (2,72) = 14.59$ and 10.23 respectively. There was also a significant three way interaction, $F\ (2,\ 72) = 4.38\ p < .05$. Scheffe tests carried out indicated that there are significantly more six word crossed context lists with a Straight prime than a Nonsense prime. Easy crossed category lists are significantly more frequent on Immediate recall than Delayed recall. The

**Figure 19: Mean number of lists with all six words recalled (a) in the correct positions, (b) in the switched positions & (c) with position errors.**



Difficult crossed category lists showed no significant effect of either Prime or Recall condition. The three way interaction shown in Figure 19 indicates that the Straight Prime/Delayed condition resulted in the highest accuracy on crossed context lists but the least on easy crossed category lists.

2. <u>Six word lists in correct order</u>

The ANOVA (Appendix 4.5) gave significant main effects of Prime and of List. Significant interactions were also found between List and Prime and List, Prime and Recall $F(2,72) = 5.32$ $p < .01$. Only easy crossed category lists showed significant differences, with significantly more lists correctly recalled when recall was Immediate than when it was Delayed when the Prime was Straight.

3. <u>Lists in Switched order</u>

The number of easy and difficult lists which were recalled was very small in comparison with crossed context lists. The crossed context lists were therefore analysed separately. ANOVA summary table is given in Appendix 4.6. Both main effects of prime and recall were significant, $F(1,36) = 12.87$ $p < .01$ and 4.93 ($p < .05$) respectively. There were more switched lists when recall was delayed than immediate and more with a Straight prime than a Nonsense prime. The ANOVA (Appendix 4.7) on easy and difficult lists showed no significant differences.

Since the results indicated that easy crossed category lists had significantly fewer correct responses on the Straight prime delayed recall condition an analysis of commission errors was carried out on these lists. Commission errors were classified as intrusions from the previously heard list or as non-instrusions. In order to give a chance estimate of intrusions the lists presented with a nonsense prime were scored as if they had been presented with a straight prime. The results are given in Table 35 which shows the relatively high number of intrusions in the Straight prime delayed recall condition. A three way ANOVA was carried out, the full results of which are given in Appendix 4.8. Significant effects of Recall and List were found and the List x Prime and List x Recall x Prime interactions were also significant. Three way interaction = $F(1,36) = 5.52$ $p < .05$. This confirms the hypothesis that there were significantly more commission errors which were intrusions from the immediately preceding list.

Table 35 : Mean number of commission errors on easy crossed category lists which were intrusions from the preceding list and those which were not.

| | Straight Prime | | Nonsense Prime | |
|---|---|---|---|---|
| | Intrusions | Not Intrusions | Intrusions | Not Intrusions |
| Immediate | 0.6 | 2.1 | 0.5 | 3.2 |
| Delayed | 4.1 | 2.7 | 1.2 | 4.4 |

<u>Discussion</u>

The results of this experiment give rather better evidence of differences between the processing of context and category. However, some conclusions made, would depend on the scoring system used. A more straightforward comparison of the two systems can be made in this experiment. A summary of the ANOVA results is given in Table 36. If the two scoring systems were equivalent then the omissions in section 1 should give similar results to the number of lists in which all six words are identified, regardless of position. However the omissions did not show a three way interaction and did not detect the Recall effect on crossed context lists or the Prime effect on crossed category lists. Similarly the scoring of correct items resulted in main effects of Recall and List but did not show the two and three way interactions found when correct lists were scored, and therefore did not show the marked effect of the Straight prime/ Delayed Recall combination on correct responses to easy lists.

On switched responses, although two ANOVAS were carried out on lists rather than the one on items, it is much clearer that there are significantly more switched responses to crossed context lists than crossed category lists.

There seems little doubt that the method of scoring in which only lists in which all six words have been identified results in less equivocal results even though much of the data is discarded. These main results can be summarised as follows:

1. Identification of the items is significantly better on crossed context lists than on easy lists and both are significantly better than on difficult lists.

2. Crossed context lists are affected both by the Recall condition and the Prime condition; Delayed recall and Straight prime resulting in increased numbers of switched lists.

Table 36: Comparison of word and list scoring methods:

Significant ANOVA effects and comparisons

## Word Scoring

**1. Omissions**

| | |
|---|---|
| List | Diff. > Con.,Easy |
| List x Recall | Fewer omissions on Con. & Diff. with Delay. More omissions on Easy with Delay. |
| List x Prime | More omissions on Con. with Straight Prime. |

**1. Total Number of Lists**

| | |
|---|---|
| List | Con. > Easy > Diff. |
| List x Recall | Easy: Imm > Delay |
| List x Prime | Con.: Str. > Non. |
| List x Recall x Prime | Easy: Str/Imm > Str/Delay |

**2. Correct**

| | |
|---|---|
| List | Easy > Con.,Diff. |
| Recall | Imm. > Delay |

**2. Correct Positions**

| | |
|---|---|
| List | Easy > Con.,Diff. |
| Recall | Imm. > Delay |
| List x Recall | Easy: Imm. > Delay |
| List x Recall x Prime | Easy: Str/Imm > Str/Delay |

**3.Switched**

| | |
|---|---|
| List | Con. > Easy, Diff. |
| Recall | Delay > Imm. |
| Prime | Str. > Non. |
| List x Prime | Con.: Str. > Non. |

**3. Switched Positions** (2 ANOVAS)

| | |
|---|---|
| List x Prime | Con.: Str. > Non. |
| List x Recall | Con.: Delay > Imm. |

Con. = Crossed Context
Easy = Easy Crossed Category
Diff. = Difficult Crossed Category
Imm. = Immediate Recall
Delay = Delayed Recall
Str. = Straight Prime
Non. = Nonsense Prime

3. Easy crossed category lists are affected mainly by the Recall condition which has a significant effect mainly on correct responses. Immediate recall results in more correct responses than Delayed recall, particularly when the Prime is straight.

4. Within difficult crossed category lists, no significant effects of Prime or Recall were found.

In experiment 6 it was found that there was increased accuracy, in terms of the number of lists recalled with all six words present, on crossed context lists when recall was delayed, but not on crossed category lists. This was confirmed in the present experiment and the possibility that the six second delay task which involved counting provided the interference on crossed category lists was refuted.

The recall conditions clearly affected correct responses to easy crossed category, but switched responses to crossed context lists. It seems then that the delay in recall caused material to be lost from the digit/letter lists, in a way that did not occur with the difficult crossed category lists, and that this effect was particularly marked when the prime lists were straight. The analysis of commission errors on easy crossed category lists confirms that the loss of items is due at least partly to intrusions from the preceding list. Since this is not apparent on immediate recall it may be concluded that delayed recall, which is concerned more with short-term memory rather than with immediate memory allows continued processing in which recent events (within the previous fifteen seconds in this case) continue to exert an influence on the current events, if they are closely related. The fact that the combination of straight prime and immediate recall does not have this effect on easy lists suggests that, in structural terms, echoic memory rather than short-term memory is operating or, in functional terms, that responses are based on "shallow" levels, as opposed to deeper levels of processing. With a nonsense prime rather than a straight prime, the items in the previous list do not interfere either with immediate or delayed recall because they are not closely associated with the current input. On difficult crossed category lists these effects are not found because the words in the previous list are not semantically associated with the current input and the "structure priming" effect found on crossed context lists also has no discernible effect on these lists.

The major difference between crossed context and crossed category lists is that in one, processing can reach a higher semantic level than in the other. Crossed context lists can be processed to a contextual level while crossed category lists cannot.

If early stages of processing are concerned more with physical features and later stages with more elaborate semantic coding it explains why the two lists show opposite effects on the Straight prime/Delayed recall condition. Crossed context lists receive continued processing which strengthens the contextual cue at the expense of the physical cue and allows the six words to be perceived as two units. The straight prime has led to an expectancy or response bias for this kind of list. With crossed category lists processing can only reach a lower level, where the items are recognised as numbers and letters and holding them in this relatively unelaborated form allows interference from previous lists. This formulation suggests an automatic process where interference from previous lists cannot be easily inhibited.

Unfortunately the basis of this interference may be acoustic, semantic or both. Within digit/letter lists there is a considerable amount of acoustic similarity as well as semantic relationships, and this was not controlled for in the design of the stimulus lists. Qualitative aspects of the performance of subjects provided some interesting results. For instance, during scoring it was noted that two of the easy crossed category lists frequently produced commission errors:

| | | | | | |
|---|---|---|---|---|---|
| List 28 consisted of | Right Ear : | Three | Ten | One | and |
| | Left Ear : | Y | V | O | |
| List 29 consisted of | Right Ear : | J | Six | E | |
| | Left Ear : | Five | N | Ten | |

Recall of list 29 frequently included an intrusion of the letter Y. It might seem that the acoustic similarity of "Y" and "Five" was the cause of this interference. However, list 47 also produced consistent commission errors. With

| | | | | | |
|---|---|---|---|---|---|
| list 46 composed of | Right Ear : | D | H | G | and |
| | Left Ear : | Three | One | Four | |
| list 47 composed of | Right Ear : | Z | Three | D | commission errors on |
| | Left Ear : | Six | L | Five | |

list 47 of the number eight were not uncommon, and were more frequent than the letter G which would be predicted if interference was acoustic. The number eight had not appeared in any of the six preceding lists, so the only explanation gleaned from the lists themselves is that subjects counted up the numbers in list 46 and that this elaborated coding produced interference. Broadbent and Gregory's (1961) implication that we know what task the subject is performing only when he produces all six items from such lists would seem to be both more and less accurate than was supposed.

However, there were, of course, many other commissions where there was no apparent reason for the errors and the above interpretations remain only intriguing possibilities which are better investigated in a controlled way than through micro-analysis of the current data.

The use of the word "prime" in this experiment may be somewhat confusing since it has generally been used in the context of word-priming, such as in the studies of Jacobson (1973), Loftus (1973) and Conrad (1974) where associations between words have been shown to have a facilitatory or inhibitory effect on processing. In contrast, the priming lists in the current experiment were designed to be "structure-priming" where, with straight priming subjects would be led to expect to hear contextual phrases in one ear and the other, or associated words in one ear or the other. The proposed difference between the easy and difficult lists was the hypothesis that digits and letters would be more closely associated than the word categories used in the difficult lists. This latter proposition is, in a sense, borne out by the finding that difficult lists are not as well recalled as easy lists. However, in hindsight it seems that two different kinds of priming were in operation.

On crossed context lists the structure-priming does indeed lead to a higher number of switched responses. Priming in this sense is more like the effects of instructions. In Gray and Wedderburn's (1960) experiment subjects chose to group by meaning more when they were told to expect a phrase, than when they were not so informed. Shinar and Jones (1973) have also found effects of set-inducing instructions in a divided attention task. Recall (of digits) was found to be better when subjects expected to recall from a particular source. Hudson and Austin (1970) also found that recall of category names was improved, when either the category name or one of the words belonging to the category was given as a cue.

However Hede (1978) did not find that awareness of list structure, in this case straight or crossed structure, had any effect on recall. His stimulus material consisted of digits and letters and subjects were instructed to report by category or ear by ear. On crossed lists, recall by category was significantly better than by ear but there was no significant difference between the scores of those who knew the structure of the lists in advance, and those who did not. This clearly differs from the results of Gray and Wedderburn (1960). However, in likening the effects of awareness/unawareness to the straight and nonsense primes used in this experiment, the same lack of significant effect is found on the digit/letter lists, except, of course, when recall is delayed. So, it can be proposed that with crossed context lists the priming in this experiment and that of Gray and Wedderburn (1960) was in some way "structure priming" but the priming on easy crossed category lists was word-priming in which the digits and letters of the preceding list caused interference when time allowed. Although the difference was not significant, comparison of straight and nonsense primes on easy lists when recall was immediate suggests that the straight primes may have facilitated immediate recall while having an actively damaging effect on delayed recall.

Recall of difficult crossed category lists was poor and interpretation must therefore be cautious, but the lack of significant effects suggests that no priming was taking place at all. The preceding lists were structurally identical but semantically different, and there were therefore neither facilitatory nor inhibitory effects.

Finally, the subjects' perceptions of the task and of their own performance are of some interest. At the end of the experiment subjects were asked if they had listened to one ear and tried to 'pick up' the words in the other or had listened to both ears equally. No significant differences were found between the different conditions and overall there were nineteen subjects who reported listening to one ear and fourteen who said they had had tried to listen to both. The other seven subjects said they had used both strategies. Table 37 shows the mean number of correct and switched responses to crossed context lists made by those subjects who reported listening to either one ear or both ears. There is some indication that listening strategy adopted affected the number of switched reponses with a higher proportion from those who reported using the two ear strategy. It may also be the case that the two ear strategy is more effective than the one ear as shown in the total column. Similar scores are found using list rather than item responses.

Table 37 : Mean correct and switched responses depending on listening strategy adopted and overall means (Position 2 responses).

| Listening Strategy | | Correct | Switched | Total |
|---|---|---|---|---|
| 1 ear | N=19 | 5.79 | 6.84 | 12.63 |
| 2 ear | N=14 | 5.5 | 10.5 | 16.00 |
| Total | N=40 | 5.43 | 8.15 | 13.58 |

Subjects were also asked if they had noticed "anything peculiar or out of place about any of the lists". Only twelve of the forty subjects gave replies indicating that they had noticed that phrases or categories were crossed on ear to ear. One such comment was typical. "Some of the lists which made up phrases seemed to be mixed with one half of the phrase coming from one ear and the other half coming in the other ear, but I can't be sure".

Subjects were also asked for any other comments and some subjects mentioned that it was difficult to remember which ear the words had been heard in. Another subject in the straight prime/delayed recall condition noticed that "when there were numbers and letters to be remembered it was more difficult to join the dots and when I concentrated on joining the dots it was difficult to remember the numbers".

This comment suggests, that at least for this subject, the delay task, was successful in preventing maintenance rehearsal but since she clearly tried both strategies it, and the other results also indicate how difficult it is to exert external control over the strategies or control processes, that individual subjects will use in any given task. This point is returned to in the general discussion in chapter 8.

# STRUCTURAL AND FUNCTIONAL FACTORS AFFECTING SELECTIVE RESPONSE TO COMPLEX AUDITORY INPUT

## Chapter 8. General Discussion

These experiments have addressed themselves to various aspects of information processing within a specific experimental paradigm, which was widely used in the 1950s, 60s and early 1970s. It has largely fallen from favour since that time and has certainly made less contribution to recent developments in the past decade.

Attention tasks nowadays are more likely to take the form of the experiments of for instance, Schneider and Shiffrin (1977) and, as mentioned in chapter 6, their postulates regarding divided and focused attention do not easily apply to any or all experiments in that field, but are mainly concerned with paradigms in which variations of the consistent mapping and varied mapping variables apply. Nevertheless, it is hard to see how auditory attention can be divided in any way other than by some variation on the dichotic listening task.

There are two main difficulties in discussing the results of the current experiments. The first relates to the problem outlined above. These experiments were designed in the mid-1970s when concepts such as automatic and controlled processing or conscious and unconscious processing were in their infancy. It is now hard to believe that in the space of ten years there has been such a radical change in experimental method and current thinking. As the review of the literature reflects the major controversay in the 1960s was whether selection was a stimulus or response phenomenon. Such arguments have been largely superseded although it is true to say that the early work of Broadbent, Treisman, Moray and the Deutschs contributed greatly to the evolution of almost every aspect of current thinking, in the related fields of attention and memory. These two areas are also more closely linked, and rightly so, than was apparent, at least in experimental design twenty years ago and it has become increasingly clear that the two cannot be easily separated.

The second difficulty lies in the fact that the experiments carried out did not necessarily follow on in a logical fashion, one from the other. Discussion would be simpler had hypotheses generated by one experiment been used to design the next and so on. The first four experiments were carried out to confirm that the phenomenon of switched responses to crossed context lists was a recall phenomenon rather than a report phenomenon, and the last four experiments either followed up hypotheses suggested by the first four or examined the effect of variables, such as rate and delay, which had been shown to effect divided and focused attention in the past. The major variables of interest have been shown to interact in a sometimes complex way. This is particularly well illustrated in experiment 5, where the input variable (rate) interacted with the structural components of list type and word position.

Crossed context lists provided the focus for all the experiments carried out and the results for these kind of lists can be summarised in terms of the probability of different variables resulting in either correct responses, switched responses or omissions. Table 38 gives these data for experiments 1, 2, 6 and 8 which used immediate or delayed recall and (in retrospect) different prime lists, in the sense used in experiment 8.

Table 38 : Omissions, correct and switched responses in experiments 1, 2, 6 and 8 (taken from percentage responses to second position words on crossed context lists.

| | Omissions | Correct | Switched |
|---|---|---|---|
| 1. Immediate Recall | | | |
| Exp 1 Straight Prime | .36 | .25 | .38 |
| Exp 8 Straight Prime | .32 | .27 | .42 |
| Exp 8 Nonsense Prime | .37 | .38 | .24 |
| Exp 6 Mixed Prime | .39 | .39 | .22 |
| Exp 2 Disordered Context Prime | .39 | .3 | .3 |
| 2. Delayed Recall | | | |
| Exp 8 Straight Prime | .23 | .18 | .59 |
| Exp 8 Nonsense Prime | .32 | .26 | .4 |
| Exp 6 Mixed Primes | .35 | .29 | .37 |

Table 38 shows that there was relatively little variation in the percentage of omissions over the eight conditions represented. With the exception of the Straight Prime/Delayed recall condition, there was no more than 7% difference. On correct and switched responses there was greater variation, 14% (disregarding the straight/delayed condition) and 20% respectively. The table shows how the balance of probability changed over the experiments so that with immediate recall, a straight prime resulted in more switched responses and fewer correct responses. With a nonsense prime and mixed primes where any of four different list structures preceded the crossed context lists, the balance shifted to correct responses and where disordered context lists were consistently presented, the balance was about equal.

The effect of delayed recall was very clearly to shift the balance of probability onto the context cue away from the physical cue of spatial location. With a straight prime this effect is particularly marked and results in a significantly smaller number of omissions as well as increased switched responses and reduced correct responses.

It would therefore appear that the combination of straight prime and delayed recall not only leads to enhanced contextual coding but allows a reconstructive process to operate so that words which under conditions of immediate recall and/or primes which were not straight would have been omitted are accurately recalled. This reconstructive process was also apparent in experiment 3 where degraded contextual inputs still resulted in nearly 18% of the second position words being recalled both as the context word and in the switched position. The study of Warren and Warren (1970) which showed a phonemic restoration effect which was dependent on context, gave similar results.

So, the first conclusions from these results are concerned with processing of crossed context lists and can be summarised as follows:

1. Given conflicting physical and contextual cues, the probability of a response based on one or the other depends on complex variables which can be manipulated experimentally.

2. Structural expectations conforming to grammatical rules, can be set up to increase the probability of a response based on context.

3. Delayed recall will increase the probability of a response based on context.

4. Reconstruction of the input occurs to a greater extent during delayed recall.

The second group of results are those concerned with the recognition, rather than the recall of position information, gained in experiments 4 and 5. Table 39 sets out these results.

Table 39 : Omissions, correct and switched responses to crossed context lists in experiments 4 and 5.

| | | | | Omissions | Correct | Switched |
|---|---|---|---|---|---|---|
| 1. | Rate: 500ms | | | | | |
| | Exp 4 | 6 word lists Position (Straight Prime) | 2. | .17 | .20 | .53 |
| 2. | Rate: 400ms | | | | | |
| | Exp 5 | 8 word lists Position (Mixed Prime) | 1 | 0 | .45 | .46 |
| | | | 2 | .08 | .25 | .36 |
| | | | 3 | .06 | .39 | .42 |
| | | | 4 | .01 | .54 | .35 |
| 3. | Rate: 1200ms | | | | | |
| | Exp 5 | 8 word lists Position (Mixed Prime) | 1 | .01 | .47 | .4 |
| | | | 2 | .03 | .46 | .26 |
| | | | 3 | .01 | .53 | .25 |
| | | | 4 | .01 | .6 | .21 |

The results of experiment 5 have been discussed at length, with regard to position effects, rate effects and the interaction of these variables with recognition of two words from the lists. The main results can be summarised as follows:

1. At a fast presentation rate (ie. 1 dichotic pair per 400 ms) there is an almost equal tendency towards correct and switched responses (spatial and semantic cue).

2. At a slow presentation rate (ie. 1 dichotic pair per 1200 ms) correct responses predominate.

3. The effects of presentation rate interact with position variables, so that at either rate, items at the end of the list are more often reported in the correct position.

4. Rate and position variables also interact with the recognition of the two required words in such a way as to give evidence that a decision made about one word influences the decision about the other word.

As regards the first two points, it is suggested that this is a manifestation of the difference between a control process of maintenance rehearsal utilised consciously by the subjects at the slow presentation rate and coding rehearsal (Shiffrin, 1976) or processing to a deeper level of analysis (Craik and Lockhart, 1972) which proceeds relatively automatically at the fast presentation rate.

The results of the position data suggest that the final item in the list is preserved in immediate (sensory or echoic) memory and is therefore more easily matched to the correct position than are items earlier in the list. The use of a "report" paradigm, in addition to the recognition task, might well elucidate this point further. The hypotheses would suggest that the most recent item preserved in immediate memory in the way suggested, would be written down first and the decision made about the last item would determine the position response of the earlier word. Although the current data suggests this interpretation, it could be confirmed by watching the subjects' behaviour as they respond to the stimuli. As with the other experiments reported here, the combination of experimental paradigms utilising recall, recognition and report strategy and even the small number of variables investigated here, seems to border on the infinite!

To return to experiment 5, it will be noted that there is a higher number of switched responses in experiment 4, compared with experiment 5. This may be because of the straight primes used in the former, the 100 millisecond discrepancy in presentation rate, or because of the shorter lists. There is also a discrepancy between the total number of lists presented to each subject. In experiment 4, only 24 lists of two different types were pre sented, while in experiment 5, 96 lists of four different types comprised the stimulus material. The data concerned with priming in later experiments and the possible use of different strategies over time and fatigue effects make it impossible to compare the two experiments. This well illustrates the difficulties presented in Chapter 2 of carrying out systematic investigation with control of all relevant variables!

In experiment 5 responses to crossed words and words which were not crossed depended both on rate and position and it is clear that responses to the lists will depend largely on the independent variables built into the experiment, and also, what dependent variable is used.

With crossed category lists a rather different picture emerges. These were investigated in relation to crossed context lists in experiments six and eight with free recall and in experiment 5 with the recognition probe. The omissions, correct and switched responses are shown in Table 40.

The statistical analyses of the data in the experiments showed no significant effect of rate or of delayed recall in experiments 5 and 6 and an effect of delayed recall, in experiment 8 only when there was a straight prime and on category lists consisting of digits and letters. The effect of the straight prime and delayed recall was opposite to that found on crossed context lists, but, as discussed in chapter 7, this does not necessarily suggest a qualitative difference between crossed context and crossed category lists since the primes in the former were neither acoustically similar nor semantically similar while they were in the latter. There was considerable evidence that there were interference effects on the digit/letter lists from the prime lists. However reference to Table 40 indicates a consistent, though small, increase in switched responses to category lists with delayed recall. This was not the case with omissions, which suggests that delayed recall did not just give more time for the subjects to make errors. Similarly, Table 40 shows that, in experiment 8 the difficult crossed category lists showed a higher rate of switching with straight primes than with nonsense primes, both on Immediate and Delayed recall, although this difference was not significant. Again, in experiment 5, there were more switched responses at the fast rate of presentation than the slow rate, so it can be said that all these results from crossed category lists are in the same direction as those from crossed context lists although they did not reach the required significance level. On the other hand in experiment 5 the crossed category lists did not show a significantly higher number of switched responses than nonsense lists but did do so in experiment 6.

Table 40: Omissions, correct responses and switched responses to crossed category lists in experiments 5, 6 and 8.

| Experiment 5. Mixed Primes. | | Omissions | Correct | Switched |
|---|---|---|---|---|
| | Position 1. | .06 | .42 | .18 |
| | 2. | .07 | .32 | .25 |
| Rate: 400ms. | 3. | .15 | .39 | .26 |
| | 4. | .06 | .42 | .24 |
| | 1. | .06 | .36 | .21 |
| | 2. | 0 | .4 | .21 |
| Rate: 1200ms. | 3. | .04 | .31 | .24 |
| | 4. | .08 | .57 | .13 |
| Immediate Recall | | | | |
| Experiment 6. | Mixed Primes | | | |
| | Mixed Category | .33 | .52 | .13 |
| Experiment 8 | Straight Primes | | | |
| | Letter/Digit Lists | .22 | .67 | .07 |
| | Mixed Category | .5 | .37 | .12 |
| Experiment 8. | Nonsense Primes | | | |
| | Letter/Digit Lists | .24 | .64 | .08 |
| | Mixed Categories | .51 | .37 | .08 |
| Delayed Recall | | | | |
| Experiment 6. | Mixed Primes | | | |
| | Mixed Categories | .43 | .38 | .18 |
| Experiment 8. | Straight Primes | | | |
| | Letter/Digit Lists | .34 | .46 | .17 |
| | Mixed Categories | .5 | .25 | .23 |
| Experiment 8. | Nonsense Primes | | | |
| | Letter/Digit Lists | .26 | .52 | .17 |
| | Mixed Categories | .44 | .34 | .16 |

Overall, there is not sufficient evidence to show that the processing of crossed category lists is qualitatively different from crossed context lists although it is certainly the case that context provides a far more powerful semantic cue than category names. Comparisons between many of the early experiments which used different kinds of contextual or categorical lists must therefore be suspect, as suggested in Chapter 2. On balance, the data presented indicates that there are not qualitative differences between the processing of context and category and the quantitative differences are based on the extra cues available in crossed context lists, through grammatical rules,familiarity or whatever. These differences could also stand further investigation in a better controlled fashion.

The conclusions made earlier about crossed context lists must therefore stand, albeit with a question mark, for crossed category lists with one further premise: that recently heard items will interfere if they are acoustically and/or semantically similar to the ongoing input and if time is given for them to do so. This is probably true of crossed context lists, as well but was not tested. The interference found on digit/letter lists in experiment 6 also suggests that where maintenance rehearsal is difficult or impossible, the coding process continues to gather evidence, where evidence is concerned not only with general knowledge, grammatical rules etc, but also recent events. When recall is immediate there is not sufficient time for the inputs to reach a "high" level of processing, where semantic properties of the word are recognised and they can be reported on the basis of lower level properties. When they must be held for some seconds, previous similar inputs cause interference. In the final experiment the time between each message was approximately twenty seconds and one might not expect intrusions from previous messages over that period of time. However, the response to the previous message occurs up to only two seconds before the following one. The delayed recall of the first message therefore may allow a more permanent, higher level trace to be formed which is therefore still available to cause interference when the second message arrives. On this hypothesis crossed context lists might show even greater interference if semantically similar lists were presented, as opposed to structurally similar lists, immediately preceding the target lists.

The question of how far these processes are conscious or unconscious can also be addressed. From the questionnaire results of experiment 8, when only twelve out of forty subjects noticed the crossed position of context and/or category, it would seem that the switched responses were made unconsciously, as was originally suggested and as much of the data implies. The certainty judgements, given in the first experiments also suggest this since subjects were no more certain of their correct responses than their switched responses to crossed context lists, although they were more certain of their responses to straight context lists. There is certainly no evidence to suggest that subjects utilised organisational strategies in a conscious fashion in such a way that caused switched responses. In general, then, it seems plausible that the choice to be made between the context cue and cue of spatial location is one which is made largely unconsciously and whether or not one or other cue is followed will depend on various factors, some of which have been demonstrated in these experiments, to give a bias towards sensory or semantic features.

A necessarily uncontrolled factor in these experiments was the kind of strategies which subjects chose to adopt. As the questionnaire results from experiment 8 indicated, different subjects did adopt different listening strategies and some changed from one to another during the experimental task. The data suggest that the adoption of the strategy of attempting to listen to both ears equally is both more successful than that of listening to one ear and trying to "pick up" the other, but also that it results in a greater number of switched responses, as compared with correct responses.

Where report strategy is controlled, (ie. where subjects are instructed to use pair by pair or ear by ear recall) it is easier to know what task the subject is performing but such report strategies may obscure what the subject would "normally" perceive.

In the focused attention experiment subjects were instructed to ignore the stimuli arriving in one ear, and in general they showed great proficiency in doing so. However it was clear from the higher number of omissions and fewer correct responses on crossed context and category lists, compared with straight context and nonsense lists, that the "unattended" input did cause interference where the spatial and semantic cues conflicted. The results of that experiment are, however, no more revealing about the reality of a filter at the input end of processing as opposed to the response end.

The results of the questionnaire in experiment 8 may suggest that filtering, as proposed by Broadbent (1958, 1971) is a control process, similar to that of rehearsal or the adoption of different listening strategies, as opposed to one which occurs naturally, because the central processor cannot carry out parallel processing. But these results still cannot discriminate between a filter which operates by attenuating the unwanted items at input and the functional view whereby the instructions to the subjects give a much higher bias towards the selection of items from one ear rather than another. The difficulty of distinguishing between the two theoretical stances is well illustrated by the different descriptions given to similar processes by Broadbent (1982) and by Shiffrin and Schneider (1977).

Broadbent (1982) used the analogy of a searchlight which has the option of altering its focus - "When it is unclear where the beam should go, it is kept wide. (divided attention) When something seems to be happening, or a cue indicates one location rather than another, the beam sharpens and moves to the point of maximum importance". (focused attention) This neat analogy provides an explanation of filtering from an early selection theorist. In discussing the distinctions between automatic and controlled processing Shiffrin and Schneider (1977) suggest that "controlled search can usually be directed to locations that the subjects desires to attend to but that automatic attention responses can overwhelm the controlled processing system and can cause attention to be allocated to positions that should be ignored". These essentially early and late selection views both provide an explanation for the data on focused attention, and are couched in such different terms that it is difficult to distinguish between them. The difference between the two positions is not fundamentally different from that discussed by Treisman and Geffen (1967). See figure 3 in chapter 1, page 8 . To a certain extent whether one takes an early or late selection, automatic and controlled, conscious and unconscious stance will depend largely on personal preference and the kind of experimental paradigms utilised.

The main results of the current experiments suggest that models of divided and focused attention should incorporate components which can deal with the effects of fast rate, delayed recall and structured priming in increasing the probability of producing switched responses. Such a model must also have a reconstructive or verification component to explain the interactive elements between critical and other words in experiment 5 and to explain the effects of delayed recall in producing more accurate responses (under certain conditions) than immediate recall. The data also suggest that the meanings of words are processed in an unconscious or automatic way. As Shiffrin, Dumais and Schneider (1981) have pointed out, automatic and controlled processing are theoretical states and, in most tasks, the contribution of each is difficult to measure. In a sense the task of listening to one source of words and understanding their meaning is surely automatic. The main properties of automaticity are said to be,that it is unavoidable, without capacity limitations, without awareness, without intention, with high efficiency and with resistance to modification (Laberge 1981). It may also need considerable amounts of practice to develop eg. Hirst et al (1980). Those authors assumed that comprehension which included the understanding of new sentences could not be automatic but their subjects did show some understanding of the meaning of dictated words while simultaneously reading. In experiment 8 the straight context priming may be likened to the constant mapping condition and the nonsense prime to the varied mapping condition of Schneider and Shiffrin (1977) with automaticity contributing more in the straight prime condition than in the nonsense prime condition.

As has probably been evident this author's personal preference lies with models such as those of Craik and Lockhart (1972), Neisser (1967) or Schneider and Shiffrin (1977).

Neisser's view of cognitive processing allows for the subjects' expectations, general knowledge etc. to influence perception, the effect of rate can be explained in terms of the active reorganisation of stimuli at a slow rate (maintenance rehearsal) as opposed to a fast rate (coding rehearsal). The model of analysis-by-synthesis suggests a reconstructive process whereby the subjects use phonemic, phonetic, syntactic or semantic rules to reconstruct what has been heard, and the rules that are used will depend largely on the experimental requirements, or as Neisser (1967) puts it "the constructive act is closely controlled by present or recent stimulus information". (p305). Neisser's view of attention and memory are not always in accord with his explanation of the general theory of cognitive processing. For instance, in the former, the pre-attentive processes seem largely confined to crude physical attributes of the stimuli while in the latter, context and experience etc. may play a central role in processing. Shiffrin and Schneider (1977) make greater allowance for semantic properties within the automatic process. Laberge (1981) makes this even more explicit in suggesting that "all familiar items in the sensitive portion (of the visual field) are processed to their representative perceptual code and in some cases, to the phonological name codes and meaning networks as well".

With regard to the operation of short term memory or active verbal memory Shiffrin and Schneider (1977) point out that automatic and controlled processing may occur in parallel so that when a fast response is required, for instance in immediate recall, it may be based on "features available at a certain point in time, even though better features might be available at a later point in time". If the words "higher level" are substituted for "better" the fact that immediate recall shows more of a bias towards the lower level feature of spatial location while delayed recall shows a swing towards the higher level features of context is readily comprehensible. Short-term memory is therefore seen as a continuum which may hold information at different levels of processing and selection of information or filtering is a control process which will operate according to the demands of the task.

Neisser (1967) pointed out that there was a practical problem in his theory in that "if what the subject will remember depends in large part on what he is trying to accomplish, on his purposes, do not predictions become impossible and explanations ad hoc?". (page 304). This is indeed a weakness of the theoretical position taken here since the largely unconscious weighing up of probabilities which is suggested, depending largely on individual knowledge, expectations etc, to say nothing of general health, mood, motivation and the like, will affect every single response which a subject makes within an experimental situation.

In this connection it is interesting to note that some studies which have shown individual preference for material have been carried out. Dodwell (1964) presented dichotic pairs of words with different frequencies in the language and with different emotional content. "Good" words were more likely to be perceived than "bad" words but there were indications that individual differences affected these responses. Personality, as measured on Eysenck's Personality Inventory, was assessed and though the results did not reach significance, it appeared that more introverted subjects showed a greater response preference for good words than did the more extroverted subjects. Under stressful conditions this effect was reduced.

Not only does this experiment suggest that individual differences, whether of personality or as measured in other ways, may be important in how such stimuli are perceived but it shows again that variables, apparently unrelated to the experimental task may interact so as to emphasise or reduce different perceptual effects.

It is clearly impossible to explain why one subject in experiment 8 produced only three switched responses to crossed context lists while three others responded by context on seven occasions. These differences must be generated by individual expectations, knowledge, practice and use of different strategies and it is clearly very difficult to control all relevant variables within one series of experiments, let alone across different series.

Before moving to the conclusions, it is worth considering some of the questions of methodology which were raised in chapter 2. Discrepancies in the use of some variables were noted in the studies of Broadbent (1954), Moray (1960) and Treisman (1971). The effect of practice and the number of lists presented were noted and are likely to be of importance in current models of information processing. The effect of individual differences may even out when fifty different lists are presented, but may not over ten lists. The concept of automatic processing is heavily reliant on extended practice and it can be proposed that such processing will develop to a greater extent, the more practice trials are given and the more lists which are presented during the experimental task. Underwood (1974) demonstrated that one highly practised subject could carry out a target identification task, while shadowing, with much higher efficiency than could subjects with no experience of the shadowing task.

Other experimental variables in the three studies are now clearly of more importance. The inter-list interval was reported only by Moray (1960) while that of Treisman (1971) was apparently under subject control. Given the effect of delayed recall in the current experiments where digit/letter lists showed evidence of interference from preceding lists and where responses to crossed context lists, and to a lesser extent, disordered context lists, showed enhancement of contextual cues, it seems likely that the amount of time given to reproduce the stimuli will have some effect on responses given. This may influence the kind of control processes utilised as well as allowing a greater or lesser amount of coding. Inter-list interval should, at least, be reported, and is probably worthy of further investigation in its own right. The manipulation of some of the variables which were clearly regarded as incidental in many of the early studies might prove fruitful experimental ground.

The scoring of lists of this type has long been recognised as problematic. Broadbent (1954) scored "lists correct", Moray (1960) used mean error scores and Treisman (1971) used mean per cent correct. She also analysed order and omission errors. In the current experiments some attempt was made to compare the results of different scoring methods. It is clear that semantic differences in the lists led to different patterns of error, with switched responses predominating on crossed context lists, and order errors more frequent on category and disordered context lists. Broadbent's method of scoring does indeed give a clearer picture of what task the subject is performing but this does not invalidate the use of item analysis. In experiment 1 the analysis of omissions made it clear that the crossed context did not only affect the words in the second position, but also the first position words, showing that the crossing had a retroactive effect. Analysis of order errors, separate from switched responses, gave some indication that disordered context also showed a small tendency towards reconstructed context. In general, Broadbent's scoring method allows one to see the wood for the trees but it is probably helpful to see both.

The use of both methods also shows how the reconstructive component of processing may occur. Where there are errors the probability of following context is lower than when all six words have been correctly identified. If one item is lost, or altered, through interference, there is one less component in the equation to be used in the analysis and the response is correspondingly less likely to be based on context. The state of evidence for context will be that much lower.

It seems unlikely then, that we can now say that it is more or less difficult to switch attention from ear to ear than from category to category as Broadbent and Gregory (1964) suggested. Responses to dichotic lists of this kind will clearly depend on what variables are manipulated, what kind of structures the lists posess and what kind of task the subjects are asked to perform. The probe task in experiment 4 produced similar results to those of the recall task in experiment 1 but replications of experiments 6 and 8 using a probe might not do so. It is clear that different kinds of rehearsal as proposed by Craik and Lockhart (1972) and Shiffrin (1976) have differential effects on recall and recognition, with maintenance rehearsal increasing recognition more than recall eg. Woodward et al (1973).

Perhaps the greatest value of these experiments is in the demonstration of complex interactions which depend on the variables manipulated and perhaps on variables which are chosen for analysis. Any of the latter experiments could be (and sometimes were) analysed in numerous different ways. In experiment 5 for instance the data can be analysed for ear advantage, practice effects, same ear or different ear for critical and other words, distance between critical and other words and no doubt others, in addition to the variables of rate, word position, critical and other words and list type which the experiment was designed to investigate. Many of these variables are likely to interact with each other and with presentation variables such as rate, with report instructions and with response variables such as delayed recall.

Moving into the realm of conjecture it seems possible that a hierarchy of variables could be constructed through the careful manipulation of factors so that the weighting of each might be calculated. Some of these will have additive effects, such as was found with structure priming and delayed recall, while others may cancel each other. A slow rate, for instance, might negate the delay effect found in these experiments. However, it should be possible to map some of the crucial variables which affect perception of context and for better controlled comparisons to be made between contexts and categories of greater and lesser difficulty.

In conclusion, the current experiments may suggest that processing occurs along a continuum from early sensory analysis through stages of processing which become increasingly complex. This is essentially the view of Craik and Lockhart (1972). The evidence for different levels of processing occurring over time is overwhelming but there have been too few studies which examined the role of different levels of analysis within rather than between ranges of sensory, phonetic or semantic stimuli. The attempts to do so within the current experiments, by comparing crossed context and crossed category lists have not been entirely successful in elucidating any differences in processing.

The model of memory and attention which emerges from these studies differs from that of the early structural models, in which the stimuli seemed to be passed from structure to structure, from input to output with little apparent opportunity to feed items back from one "box" to an earlier one except through processes such as rehearsal.

The functional theoretical stance taken here subsumes different aspects of the theories of Neisser (1967), Craik and Lockhart (1972), Shiffrin and Schneider (1977), none of which seem incompatible. The major components then, which seem appropriate to the current data are the reconstructure elements of analysis-by-synthesis, where all inputs, knowledge, expectations, and momentary changes in bias are used in the decision-making process which, in this case, must decide between conflicting cues of spatial location and context and/or category. The distinction between two kinds of rehearsal, maintenance and coding, is apparent in the work of Craik and Lockhart (1972) and Shiffrin and Schneider (1977). Maintenance rehearsal is seen here as a control process which can be utilised by the subject at a slow rate of presentation. Coding is seen as an automatic process which operates generally outwith the consciousness of the subject and is difficult to overturn. Where maintenance rehearsal is prevented, coding will continue over time to deeper levels of analysis, with subsequent loss of earlier levels. As all three accounts imply, the level of processing will depend on how deeply the stimuli are able to be coded (eg. nonsense syllables cannot be encoded to the same level as category names which in turn cannot be encoded to the level of context). Going beyond the data presented here, it can be suggested that further encoding of stimuli such as nonsense syllables or categories can be carried out, but only through controlled processing, eg. the use of mnemonics (Though the example given in experiment 8 where subjects seemed to add up the digits presented suggests the intriguing possibility that the addition of single digits is an automatised task, at least for psychology undergraduates!).

The automatic process is one which deals with the probabilities of events where all incoming information interacts with information about past events, grammatical rules and the other factors suggested by Neisser (1967) until a decision criterion level is reached. Where that criterion level lies will often depend on the requirements of the task.

Finally, with such a model of information processing it is perhaps easier to envisage encodings as a spreading circle rather than a continuum where each incoming item generates its own ripples. These ripples will overlap and affect each other's shape if items occur closely together. As the ripples move outwards they represent the deeper encoding of each item while the inner rings, representing earlier feature analysis will fade. The size of the pool (limited by instructions) will affect how far the ripples can travel as will the size (complexity) of the initial item. The disturbance of the pool iteself can be seen as the operation of individual knowledge: the depth and contents of the pool affecting the ripples just as the ripples affect the pool.

This analogy seems apposite in accounting for the present data, and it is left for future research to determine its utility in dealing with other paradigms. There are many difficulties inherent in the use of the split span task. The preceding experiments cannot, for instance, approach the question of how far automatic and controlled processing operated in each task. Variations on the consistent and varied mapping paradigm using the split span task represent only a fraction of the interesting possibilities for future research.

STRUCTURAL AND FUNCTIONAL FACTORS
AFFECTING SELECTIVE RESPONSE TO
COMPLEX AUDITORY INPUT

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STRUCTURAL AND FUNCTIONAL FACTORS
AFFECTING SELECTIVE RESPONSE TO
COMPLEX AUDITORY INPUT

Appendices

Appendix 1.1. Experiment 1. ANOVA Summary Table: Omissions.

| Source | SS | df | MS | F | |
|---|---|---|---|---|---|
| A Lists | 553.52 | 1 | 553.52 | 46.14 | ** |
| B Positions | 235.29 | 2 | 117.65 | 26.84 | ** |
| AB | 180.54 | 2 | 90.27 | 36.84 | ** |
| A x Subjects | 83.98 | 7 | 11.1 | | |
| B x Subjects | 61.38 | 14 | 4.38 | | |
| AB x Subjects | 51.46 | 21 | 2.45 | | |

Appendix 1.2. Experiment 1. ANOVA Summary Table: Certainty Judgements

| Source | SS | df | MS | F | |
|---|---|---|---|---|---|
| A Lists | 1.13 | 1 | 1.13 | 5.74 | * |
| B Certain or Uncertain | 276.13 | 1 | 276.13 | 11.69 | * |
| AB | 435.13 | 1 | 435.13 | 188.37 | ** |
| A x Subjects | 1.38 | 7 | 0.2 | | |
| B x Subjects | 165.38 | 7 | 23.63 | | |
| AB x Subjects | 32.38 | 14 | 2.31 | | |

* = p .05

**= p .01

Appendix 1.3. Experiment 2. ANOVA Summary Table: Omissions

| Source | SS | df | MS | F | |
|---|---|---|---|---|---|
| A Lists | 0.52 | 1 | 0.52 | 0.03 | N.S. |
| B Positions | 335.79 | 2 | 167.89 | 19.13 | ** |
| AB | 171.29 | 2 | 85.65 | 30.27 | ** |
| A x Subjects | 126.31 | 7 | 18.05 | | |
| B x Subjects | 122.88 | 14 | 8.78 | | |
| AB x Subjects | 59.38 | 21 | 2.83 | | |

Appendix 1.4. Experiment 2. ANOVA Summary Table: Certainty Judgements

| Source | SS | df | MS | F | |
|---|---|---|---|---|---|
| A Lists | 0.5 | 1 | 0.5 | 1.39 | N.S. |
| B Certain or Uncertain | 4.5 | 1 | 4.5 | 0.04 | N.S. |
| AB | 40.5 | 1 | 40.5 | 3.58 | N.S. |
| A x Subjects | 2.5 | 7 | 0.36 | | |
| B x Subjects | 865.5 | 7 | 123.64 | | |
| AB x Subjects | 158.5 | 14 | 11.32 | | |

Appendix 2.1. Experiment 5. ANOVA Summary Table: Correct Responses to Crossed Context and Category Lists

| Source | SS | df | MS | F | |
|---|---|---|---|---|---|
| C Rate | 10.54 | 1 | 10.54 | 4.58 | * |
| error between subjects | 50.58 | 22 | 2.3 | | |
| A Lists | 9.63 | 1 | 9.63 | 3.87 | N.S. |
| AC | 1.51 | 1 | 1.51 | 0.61 | N.S. |
| B Positions | 31.05 | 3 | 10.35 | 7.19 | ** |
| BC | 5.94 | 3 | 1.98 | 1.38 | N.S. |
| AB | 6.02 | 3 | 2.01 | 1.68 | N.S. |
| ABC | 3.63 | 3 | 1.21 | 1.0 | N.S. |
| error within subjects (1) | 54.74 | 22 | 2.49 | | |
| (2) | 95.14 | 66 | 1.44 | | |
| (3) | 78.97 | 66 | 1.2 | | |

Appendix 2.2: Experiment 5. ANOVA Summary Table: Switched Responses to Crossed Context and Category Lists.

| Source | | SS | df | MS | F | |
|---|---|---|---|---|---|---|
| C Rate | | 10.08 | 1 | 10.08 | 6.16 | * |
| error between subjects | | 35.98 | 22 | 1.64 | | |
| A Lists | | 26.99 | 1 | 26.99 | 14.59 | ** |
| AC | | 2.53 | 1 | 2.53 | 1.38 | N.S. |
| B Positions | | 6.56 | 3 | 2.19 | 1.68 | N.S. |
| BC | | 2.92 | 3 | 0.97 | 0.75 | N.S. |
| AB | | 7.18 | 3 | 2.39 | 2.63 | N.S. |
| ABC | | 0.72 | 3 | 0.24 | 0.26 | N.S. |
| error within subjects | (1) | 40.73 | 22 | 1.85 | | |
| | (2) | 85.77 | 66 | 1.3 | | |
| | (3) | 59.85 | 66 | 0.91 | | |

Appendix 2.3. Experiment 5. ANOVA Summary Table: Position Errors on Crossed Context and Category Lists

| Source | | SS | df | MS | F | |
|---|---|---|---|---|---|---|
| C Rate | | 1.5 | 1 | 1.5 | 0.87 | N.S. |
| error between subjects | | 38.12 | 22 | 1.73 | | |
| A Lists | | 47.0 | 1 | 47.0 | 44.26 | ** |
| AC | | .01 | 1 | .01 | .01 | N.S. |
| B Positions | | 11.8 | 3 | 3.93 | 9.29 | ** |
| BC | | 2.07 | 3 | 0.69 | 0.54 | N.S. |
| AB | | 6.82 | 3 | 2.27 | 2.15 | N.S. |
| ABC | | 1.62 | 3 | 0.54 | 0.52 | N.S. |
| error within subjects | (1) | 23.36 | 22 | 1.06 | | |
| | (2) | 83.75 | 66 | 1.27 | | |
| | (3) | 69.65 | 66 | 1.06 | | |

Appendix 2.4. Experiment 5. ANOVA Summary Table: Crossed Context Lists. Correct and Switched Responses to Critical words, Correct and Incorrect Responses to Other words at each Position & Rate

| Source | SS | df | MS | F | |
|---|---|---|---|---|---|
| C Rate | 0.01 | 1 | 0.01 | 0.04 | N.S. |
| error between subjects | 6.46 | 22 | 0.29 | | |
| A Critical | 12.76 | 1 | 12.76 | 5.52 | * |
| AC | 10.68 | 1 | 10.68 | 4.62 | * |
| error (1) | 50.81 | 22 | 2.31 | | |
| B Position | 6.94 | 3 | 2.15 | 9.35 | ** |
| BC | 0.93 | 3 | 0.31 | 1.35 | N.S. |
| error (2) | 15.13 | 66 | 0.23 | | |
| D Other | 60.17 | 1 | 60.17 | 23.05 | ** |
| CD | 7.6 | 1 | 7.6 | 2.91 | N.S. |
| error (3) | 57.48 | 22 | 2.61 | | |
| AB | 9.3 | 3 | 3.1 | 2.98 | * |
| ABC | 1.84 | 3 | 0.61 | 0.59 | N.S. |
| error (4) | 68.6 | 66 | 1.04 | | |
| AD | 11.34 | 1 | 11.34 | 3.26 | N.S. |
| ACD | 10.65 | 1 | 10.65 | 3.06 | N.S. |
| error (5) | 76.5 | 22 | 3.48 | | |
| BD | 7.35 | 3 | 2.45 | 2.61 | N.S. |
| BCD | 4.04 | 3 | 1.35 | 1.44 | N.S. |
| error (6) | 62.35 | 66 | 0.94 | | |
| ABD | 4.43 | 3 | 1.48 | 5.48 | ** |
| ABCD | 6.25 | 3 | 2.08 | 7.7 | ** |
| residual error | 17.84 | 66 | 0.27 | | |

Appendix 2.5. Experiment 5. ANOVA Summary Table: Crossed Category Lists. Correct and Switched Responses to Critical Words, Correct and Incorrect Resonses to Other words at each Position & Rate

| Source | SS | df | MS | F | |
|---|---|---|---|---|---|
| C Rate | 0.02 | 1 | 0.02 | 0.06 | N.S. |
| error between subjects | 7.46 | 22 | 0.34 | | |
| A Critical | 25.52 | 1 | 25.52 | 21.45 | ** |
| AC | 1.64 | 1 | 1.64 | 1.38 | N.S. |
| error (1) | 26.28 | 22 | 1.19 | | |
| B Position | 1.65 | 3 | 0.55 | 1.49 | N.S. |
| BC | 0.64 | 3 | 0.21 | 0.57 | N.S. |
| error (2) | 24.52 | 66 | 0.37 | | |
| D Other | 6.77 | 1 | 6.77 | 5.09 | * |
| CD | 4.39 | 1 | 4.39 | 3.3 | N.S. |
| error (3) | 28.28 | 22 | 1.33 | | |
| AB | 8.6 | 3 | 2.87 | 3.68 | * |
| ABC | 2.6 | 3 | 0.87 | 1.11 | N.S. |
| error (4) | 51.61 | 66 | 0.78 | | |
| AD | 0.14 | 1 | 0.14 | 0.16 | N.S. |
| ACD | 0.03 | 1 | 0.03 | 0.03 | N.S. |
| error (5) | 19.26 | 22 | 0.88 | | |
| BD | 8.1 | 3 | 2.7 | 4.66 | ** |
| BCD | 4.35 | 3 | 1.45 | 2.5 | N.S. |
| error (6) | 38.36 | 66 | 0.58 | | |
| ABD | 2.3 | 3 | 0.77 | 1.08 | N.S. |
| ABCD | 1.37 | 3 | 0.46 | 0.65 | N.S. |
| residual error | 47.15 | 66 | 0.71 | | |

Appendix 3.1. Experiment 6. ANOVA Summary Table: Omissions recorded on Five List Types, at each Position with Immediate and Delayed Recall

| Source | | SS | df | MS | F | |
|---|---|---|---|---|---|---|
| C Recall | | 3.85 | 1 | 3.85 | 0.02 | N.S. |
| error between subjects | | 4029.89 | 18 | 223.88 | | |
| A Lists | | 3858.45 | 4 | 964.62 | 66.8 | ** |
| AC | | 150.11 | 4 | 37.53 | 2.6 | * |
| B Positions | | 1293.74 | 2 | 646.87 | 50.68 | ** |
| BC | | 41.69 | 2 | 20.84 | 1.63 | N.S. |
| AB | | 354.89 | 8 | 44.36 | 10.9 | ** |
| ABC | | 120.35 | 8 | 15.04 | 3.7 | ** |
| error within subjects | (1) | 1039.57 | 72 | 14.44 | | |
| | (2) | 459.51 | 36 | 12.76 | | |
| | (3) | 585.83 | 144 | 4.07 | | |

Appendix 3.2. Experiment 6. ANOVA Summary Table: Correct Responses Recorded on Five List Types, at each Position with Immediate and Delayed Recall

| Source | | | | | | |
|---|---|---|---|---|---|---|
| C Recall | | 228.81 | 1 | 228.81 | 0.81 | N.S. |
| error between subjects | | 4720.98 | 18 | 262.28 | | |
| A List | | 5574.12 | 4 | 1393.53 | 79.49 | ** |
| AC | | 190.39 | 4 | 47.6 | 2.72 | * |
| B Positions | | 3686.43 | 2 | 1843.22 | 104.09 | ** |
| BC | | 154.11 | 2 | 77.06 | 4.35 | * |
| AB | | 2474.44 | 8 | 309.31 | 43.66 | ** |
| ABC | | 219.29 | 8 | 27.41 | 3.87 | ** |
| error within subjects | (1) | 1262.29 | 72 | 17.53 | | |
| | (2) | 637.46 | 36 | 17.71 | | |
| | (3) | 1020.27 | 144 | 7.09 | | |

Appendix 3.3 Experiment 6. ANOVA Summary Table: Switched Responses Recorded on Four List Types (Straight Context Lists were excluded) at each Position with Immediate & Delayed Recall

| Source | | SS | df | MS | F | |
|---|---|---|---|---|---|---|
| C Recall | | 141.07 | 1 | 141.07 | 10.48 | ** |
| error between subjects | | 242.18 | 18 | 13.45 | | |
| A Lists | | 364.55 | 3 | 121.52 | 30.03 | ** |
| AC | | 16.97 | 3 | 5.66 | 1.4 | N.S. |
| B Positions | | 819.433 | 2 | 409.72 | 115.02 | ** |
| BC | | 52.93 | 2 | 26.47 | 3.72 | * |
| AB | | 1069.9 | 6 | 178.32 | 43.17 | ** |
| ABC | | 83.53 | 6 | 13.92 | 3.37 | ** |
| error within subjects | (1) | 218.48 | 54 | 4.05 | | |
| | (2) | 256.47 | 36 | 7.12 | | |
| | (3) | 446.07 | 108 | 4.13 | | |

Appendix 3.4. Experiment 6. ANOVA Summary Table: Position Errors Recorded on Five List Types at each Position with Immediate and Delayed Recall.

| Source | | SS | df | MS | F | |
|---|---|---|---|---|---|---|
| C Recall | | 4.08 | 1 | 4.08 | 4.09 | N.S. |
| error between subjects | | 17.95 | 18 | 0.1 | | |
| A Lists | | 37.19 | 4 | 9.3 | 21.82 | ** |
| AC | | 8.4 | 4 | 2.1 | 4.93 | ** |
| B Positions | | 9.93 | 2 | 4.96 | 5.99 | ** |
| BC | | 2.05 | 2 | 1.02 | 1.23 | N.S. |
| AB | | 6.17 | 8 | 0.77 | 1.51 | N.S. |
| ABC | | 8.12 | 8 | 1.02 | 1.99 | N.S. |
| error within subjects | (1) | 30.68 | 72 | 0.43 | | |
| | (2) | 29.83 | 36 | 0.83 | | |
| | (3) | 73.24 | 144 | 0.51 | | |

Appendix 3.5. Experiment 6. ANOVA Summary Table: Lists in which all six words were identified in the correct or switched positions. (Response type) with immediate and delayed recall. Crossed Context and Crossed Category Lists only

| Source | SS | df | MS | F | |
|---|---|---|---|---|---|
| C Recall | 3.62 | 1 | 3.62 | 0.38 | N.S. |
| error between subjects | 173.33 | 18 | 9.63 | | |
| A Response | 13.64 | 1 | 13.64 | 6.43 | * |
| AC | 11.99 | 1 | 11.99 | 5.65 | * |
| B Lists | 0.62 | 1 | 0.62 | 0.08 | N.S. |
| BC | 92.01 | 1 | 92.01 | 13.03 | ** |
| AB | 19.99 | 1 | 19.99 | 3.49 | N.S. |
| ABC | 2.84 | 1 | 2.84 | 0.49 | N.S. |
| error within subjects | (1) 38.13 | 18 | 2.12 | | |
| | (2) 127.13 | 18 | 7.06 | | |
| | (3) 102.93 | 18 | 5.72 | | |

Appendix 3.6. Experiment 7. ANOVA Summary Table: Number of Lists Containing an Omission. List x Recall.

| Source | SS | df | MS | F | |
|---|---|---|---|---|---|
| B Recall | 4.05 | 1 | 4.05 | 0.84 | N.S. |
| error between subjects | 67.35 | 14 | 4.81 | | |
| A Lists | 55.7 | 4 | 13.93 | 7.56 | ** |
| AB | 9.95 | 4 | 2.49 | 1.35 | N.S. |
| error within Subjects | 103.15 | 56 | 1.84 | | |

Appendix 3.7 Experiment 7. ANOVA Summary Table: Number of Lists in which all Three Words were Correctly Positioned.

| Source | SS | df | MS | F | |
|---|---|---|---|---|---|
| B Recall | 0.05 | 1 | 0.05 | 0.005 | N.S. |
| error between subjects | 126.7 | 14 | 9.05 | | |
| A Lists | 119.93 | 4 | 29.98 | 11.39 | ** |
| AB | 17.58 | 4 | 4.39 | 1.67 | N.S. |
| error within subjects | 147.3 | 56 | 2.63 | | |

Appendix 4.1. Experiment 8. ANOVA Summary Table: Omissions recorded on Second Position words in Lists of Three Types, with Straight or Nonsense Primes and with Immediate & Delayed Recall

| Source | SS | df | MS | F | |
|---|---|---|---|---|---|
| B Primes | 0.3 | 1 | 0.3 | 0.02 | N.S. |
| C Recall | 2.13 | 1 | 2.13 | 0.14 | N.S. |
| BC | 6.53 | 1 | 6.53 | 0.43 | N.S. |
| error between subjects | 543.4 | 36 | 15.09 | | |
| A Lists | 444.65 | 2 | 222.33 | 69.3 | ** |
| AB | 25.35 | 2 | 12.68 | 3.95 | * |
| AC | 41.32 | 2 | 20.66 | 6.44 | ** |
| ABC | 9.02 | 2 | 4.51 | 1.41 | N.S. |
| error within subjects | 230.1 | 72 | 3.21 | | |

Appendix 4.2. Experiment 8. ANOVA Summary Table: Correct Responses on Second Position Words in Lists of Three Types, with Straight & Nonsense Primes and with Immediate & Delayed Recall

| Source | SS | df | MS | F | |
|---|---|---|---|---|---|
| B Primes | 33.08 | 1 | 33.08 | 1.72 | N.S. |
| C Recall | 156.41 | 1 | 156.41 | 8.12 | ** |
| BC | 7.01 | 1 | 7.01 | 0.36 | N.S. |
| error between subjects | 693.43 | 36 | 19.26 | | |
| A Lists | 811.27 | 2 | 405.63 | 53.94 | ** |
| AB | 14.6 | 2 | 7.3 | 0.97 | N.S. |
| AC | 18.87 | 2 | 9.43 | 1.25 | N.S. |
| ABC | 10.46 | 2 | 5.23 | 0.7 | N.S. |
| error within subjects | 541.47 | 72 | 7.52 | | |

Appendix 4.3. Experiment 8. ANOVA Summary Table: Switched Responses on Second Position Words in Lists of Three Types, with Straight & Nonsense Primes and with Immediate and Delayed Recall

| Source | SS | df | MS | F | |
|---|---|---|---|---|---|
| B Primes | 73.63 | 1 | 73.63 | 6.32 | * |
| C Recall | 168.03 | 1 | 168.03 | 14.41 | ** |
| BC | 0.54 | 1 | 0.54 | 0.05 | |
| error between subjects | 419.67 | 36 | 11.66 | | |
| A Lists | 819.02 | 2 | 409.51 | 69.71 | ** |
| AB | 76.72 | 2 | 38.36 | 6.53 | ** |
| AC | 13.12 | 2 | 6.56 | 1.12 | N.S. |
| ABC | 0.21 | 2 | 0.1 | 0.02 | N.S. |
| error within subjects | 422.93 | 72 | 5.87 | | |

Appendix 4.4. Experiment 8. ANOVA Summary Table: Lists in which all Six Words were Correctly Identified, Regardless of Position. List x Prime x Recall.

| Source | SS | df | MS | F | |
|---|---|---|---|---|---|
| B Primes | 16.88 | 1 | 16.88 | 3.15 | N.S. |
| C Recall | 2.41 | 1 | 2.41 | 0.45 | N.S. |
| BC | 8.01 | 1 | 8.01 | 1.5 | N.S. |
| error between subjects | 192.63 | 36 | 5.35 | | |
| A Lists | 172.05 | 2 | 86.03 | 61.65 | ** |
| AB | 28.55 | 2 | 14.28 | 10.23 | ** |
| AC | 40.72 | 2 | 20.36 | 14.59 | ** |
| ABC | 12.22 | 2 | 6.11 | 4.38 | * |
| error within subjects | 100.47 | 72 | 1.4 | | |

Appendix 4.5. Experiment 8. ANOVA Summary Table: Lists in which all Six Words were Correctly Identified, in the Correct Position. List x Prime x Recall

| Source | SS | df | MS | F | |
|---|---|---|---|---|---|
| B Primes | 0.2 | 1 | 0.2 | 0.06 | N.S. |
| C Recall | 21.67 | 1 | 21.67 | 5.87 | * |
| BC | 8.01 | 1 | 8.01 | 2.17 | N.S. |
| error between subjects | 132.77 | 36 | 3.69 | | |
| A Lists | 64.05 | 2 | 32.02 | 30.12 | ** |
| AB | 5.62 | 2 | 2.81 | 2.64 | N.S. |
| AC | 11.15 | 2 | 5.58 | 5.25 | ** |
| ABC | 11.32 | 2 | 5.66 | 5.32 | ** |
| error within subjects | 76.54 | 72 | 1.06 | | |

Appendix 4.6. Experiment 8. ANOVA Summary Table: Crossed Context Lists in which all Six Words were Correctly Identified, in the Switched Position. Prime x Recall.

| Source | SS | df | MS | F | |
|---|---|---|---|---|---|
| B Prime | 44.1 | 1 | 44.1 | 12.86 | ** |
| C Recall | 16.9 | 1 | 16.9 | 4.93 | * |
| BC | 0 | 1 | 0 | 0 | N.S. |
| error between subjects | 123.4 | 36 | 3.43 | | |

Appendix 4.7. Experiment 8. ANOVA Summary Table: Easy and Difficult Crossed Category Lists in which all Six Words were Correctly Identified. in the Switched Position. List x Prime x Recall.

| Source | SS | df | MS | F | |
|---|---|---|---|---|---|
| B Primes | 0.05 | 1 | 0.05 | 0.1 | N.S. |
| C Recall | 0.45 | 1 | 0.45 | 0.87 | N.S. |
| BC | 0.45 | 1 | 0.45 | 0.87 | N.S. |
| error between subjects | 18.6 | 36 | 0.52 | | |
| A Lists | 1.8 | 1 | 1.8 | 3.95 | N.S. |
| AB | 1.8 | 1 | 1.8 | 3.95 | N.S. |
| AC | 0 | 1 | 0 | 0 | N.S. |
| ABC | 0 | 1 | 0 | 0 | N.S. |
| error within subjects | 16.4 | 36 | 0.46 | | |

Appendix 4.8. Experiment 8. ANOVA Summary Table: Commission Errors which were or were not Intrusions from the Preceding List on Easy Crossed Category Lists only. Intrusions x Prime x Recall.

| Source | SS | df | MS | F | |
|---|---|---|---|---|---|
| B Primes | 0.05 | 1 | 0.05 | 0.01 | N.S. |
| C Recall | 45 | 1 | 45 | 11.9 | ** |
| BC | 6.05 | 1 | 6.05 | 1.6 | N.S. |
| error between subjects | 136.1 | 36 | 3.78 | | |
| A Lists | 45 | 1 | 45 | 17.18 | ** |
| AB | 42.05 | 1 | 42.05 | 16.05 | ** |
| AC | 7.2 | 1 | 7.2 | 2.75 | N.S. |
| ABC | 14.45 | 1 | 14.45 | 5.52 | * |
| error within subjects | 94.3 | 36 | 2.62 | | |