

R E C E N C Y A N D P R I M A C Y E F F E C T S

I N S H O R T - T E R M M E M O R Y

by

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D E C L A R A T I O N

I DECLARE that with the exception of the assistance acknowledged in this Thesis, the whole of the experimental work described and the collection of all the material on which the dissertations are based are the results of my own studies.

I ALSO DECLARE that this Thesis has not been already accepted in substance for any Degree, nor is it concurrently submitted in whole or in part to any University in candidature for any Degree.

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ABSTRACT

One of the most consistent findings in short-term memory (STM) research is that when a list of items is presented for immediate recall, and performance is measured as a function of input serial position, recall is characterised by a bow-shaped curve whereby the beginning of the list is well recalled (the primacy effect), and the end of the list is recalled best of all (the recency effect). These twin phenomena require to be explained by any theoretical account of STM function although the crucial role occupied by recency in current theoretical debate demands that it receives particular attention.

A review of the relevant literature suggests that three broad classes of model can be identified which differ with regard to interpretations of one or other or both of the above effects. These are: (i) The modal model (eg Waugh and Norman 1965; Atkinson and Shiffrin 1968; Glanzer 1972) which explain the two effects in terms of the operation of two distinct memory stores; (ii) Levels of processing (Craik and Lockhart 1972; Craik and Tulving 1975) where the emphasis is placed on differences in the nature of the encoding operations devoted to early and late items; (iii) A recent sub-group of theories concerned only with recency, and which view the phenomenon as the operation of a specific retrieval strategy.

The experimental investigation began by discussing the apparent invariance of immediate recall recency in, for example free recall, and suggested that this could be the result of an inbuilt bias in the processing of fixed length lists. In contrast evidence was presented from experiments using a running memory span paradigm (Experiments 1 and 2) which demonstrated that terminal item recall can be affected by such factors as memory load, presentation rate, and processing strategy. The results are interpreted as showing that recency effects can reflect the output of an active processor/rehearsal mechanism given appropriate task demands.

A second series of experiments considered a second highly replicable phenomenon: the elimination of recency by interpolated activity. In particular attention was paid to the effects of varying the class of the distractor material (which did not have to be memorised) upon list recall. As the direction of any such influence was also considered important, a return to fixed length lists was demanded. The results

showed that detrimental effects attributable to class similarity were uni-directional i.e. they were present when the distractor followed the memory list (Experiment 3) but absent when the paradigm was reversed (Experiment 4). When these occurred in the post-list delay condition however, they were observed to be uniform across all serial positions. In contrast, a special condition where both memory and distractor lists were identical showed enhanced recall regardless of whether the distractor followed (post-list delay), or came before (pre-list condition), the memory items. These improvements to recall were restricted predominantly to primacy. It was argued that while the results of the delay task study are explicable in terms of most major theories (especially the modal model) the findings from the pre-list experiment argue against positions which seek to explain all primacy effects by differential rehearsal or elaborate encoding. It was concluded that in order to account for the particular survival of the early portion of a set of stimuli which does not require to be memorised, some appeal to a concept of 'primacy salience' seems necessitated.

A further series of experiments (Experiments 5, 6, 7 and 8) critically examined another aspect of the apparent invariance of serial position functions and demonstrated that when conceptually-related stimuli are grouped together during input of a memory list, consistent deviations from the standard recall profile are obtained. These are characterised by durable, within-list primacy effects, contingent upon the beginning of each block, and were evident whether the block represented a brand new category or merely a subset of a previously-presented category (Experiments 5 and 6). The effects were considered particularly amenable to explanation in terms of versions of the modal model which incorporate control processes responsive to inbuilt organisational features of the material. While it could be argued that explanation is also possible via a levels framework, it was suggested that this would result in an account virtually indistinguishable from dichotomous positions it claims to supercede.

Additional experiments with the same basic paradigm (Experiments 7 and 8), but where list length was increased to 60 items, revealed evidence of two co-occurring recency effects: (i) the typical 'immediate effect' spanning terminal items, and (ii) a parallel effect embracing

terminal groups of related items. The presence of this second effect in immediate recall effectively ruled out explanation via either of the general models, (a) because of the large number of intervening items involved which precludes the operation of a fixed capacity mechanism, and (b) because the effect's obvious dependence upon semantic features refutes any account of recency based on shallow phonemic processing. Only those models which view recency as the product of a retrieval strategy seemed capable of handling these data comfortably. Moreover such theories, which place emphasis on the 'appropriateness of the units' over which such a strategy can be applied when these are defined from the point of the recall test, received further support from tentative evidence of a list recency effect.

The final set of experiments (Experiments 9 and 10) employed a final free recall paradigm with the dual purpose of examining the negative recency effect for items (Craik 1970) and simultaneously extending consideration of the recency effect for lists encountered in Experiment 8. While evidence on the former phenomenon indicated a somewhat unreliable phenomenon, the finding of list recency in final recall was confirmed as being both reliable and substantial. Furthermore, such effects were independent of the nature of the list material, and therefore presumably determined by the organisation imposed on each list during initial learning and the position the list occupied within the series. Further evidence from cued final recall emphasised retrieval aspects of the process involved.

Based on all the evidence accumulated during the course of the investigations several conclusions were drawn :

(i) Recency effects cannot be viewed as a unitary phenomenon: At least two processes require to be postulated to handle all the relevant data. One of these involves the output from an active processor/rehearsal mechanism, while the second reflects the operation of a retrieval strategy conducted on proximal units at the time of recall. As currently formulated, only one model accepts the need to explain recency effects by recourse to more than one mechanism (Craik and Jacoby 1975).

(ii) By a similar token, an adequate account of primacy can only be given by assuming that two processes are responsible. The first of these again implicates an active processor which devotes differential

attention to the initial items in any series of to-be-remembered material, while the second assumes that the beginning of any well-defined series which the subject is set to receive will achieve some privileged storage status. The basis of this second process however, is not fully understood.

(iii) One inevitable corollary of conclusions (i) and (ii) is that no model of STM function currently in existence can encompass all the findings adequately. With reference to the effects obtained, the final section offers some comments concerning the particular weaknesses inherent in certain formulations.

CHAPTER I

INTRODUCTION AND THEORETICAL REVIEW

1 : 1	PREFACE
1 : 2	DEFINING THE LIMITS OF THE INVESTIGATION
1 : 3	THE FOCUS OF THE INVESTIGATION
1 : 4	BACKGROUND
1 : 5	THEORETICAL ACCOUNTS
1:5:1	THE MODAL MODEL
1:5:2	LEVELS OF PROCESSING
1:5:3	RECENT THEORIES OF RECENCY
1 : 6	KEY ISSUES AND THE COURSE OF THE INVESTIGATION

Research into human memory forms a substantial part of Experimental Cognitive Psychology. The reasons for this are fairly obvious and require little amplification. The ability to store and retrieve information is both central and fundamental to the vast majority of human behaviour. Without such a facility no new learning could take place, and meaningful patterns of serial activity where one action is based upon the knowledge and consequences of the previous one would become impossible. The research to be reported here is concerned with some aspects of the processes underlying such storage and retrieval operations in so far as they can be inferred from short-term memory (STM) experiments.

1 : 2 DEFINING THE LIMITS OF THE INVESTIGATION

1:2:1 Semantic versus Short-term Memory

At this point a distinction should be drawn between the processes under scrutiny in STM experiments as discussed here, and those which may apply to the organism's permanent or 'semantic memory' (c.f. for example Tulving's, 1972 distinction between episodic and semantic memory). For present purposes it is assumed that the stimuli typically employed in verbal STM tasks (e.g. digits, letters and words) already form part of the subjects' verbal repertoire. That is to say that they are already 'known' to the subject and indeed occupy some form of permanent storage space in memory. The work presented here therefore will not be concerned with how such representations are acquired initially. Nor indeed will it be concerned with how such permanent memory is organised. Rather attention will be focussed on how such material, once activated during the course of a short-term memory task, is 'reprocessed' and held in readiness for recall. While this is not to deny the possibilities of interactions between the 'semantic data base' and those operations performed upon it, these will not be the prime concern of the investigation to be reported here.

1:2:2 Sensory Memory and Short-term Memory

At the other end of the continuum a similar distinction can be made between STM experiments and those concerned with sensory storage mechanisms. Following Neisser, (1967) the terms Iconic and Echoic memory have been commonly adopted to refer to the respective visual and auditory processes involved. Typically experiments in this area have tended to demonstrate the existence of peripheral systems which operate on the incoming material at a precategorical level (see Crowder 1976) and as such are concerned with preserving the more physical aspects of the stimuli. Examples of such research in the visual modality are studies by Sperling (1960), Turvey (1973) and Phillips (1974) while equivalent landmarks in echoic memory research are provided by Treisman (1964) and Crowder and Morton (1969).

Naturally any complete account of memory storage and retrieval would require to encompass all such systems. This research however will confine itself to an examination of certain aspects of memory which fall between the extremes of semantic and sensory memory noted above. The material used as stimuli is not new in the sense that it is unknown or unfamiliar to the subject. Neither is it presented for such short durations that only part of the information can be read out from some rapidly decaying sensory store (c.f. Sperling 1960). However, the material does require to be attended to, processed and organised in some particular way in order to be held in some form of temporary storage from which it can be retrieved at the time recall is demanded. It is the nature of these operations that this body of work seeks to clarify.

One of the most enduring concerns within the field of STM enquiry has been the serial position curve - or the measurement of recall performance as a function of each item's input position within the list or lists being studied. This has highlighted a number of intriguing phenomena which have provided the source of much theoretical debate. Of particular interest have been the two phenomena of Primacy and Recency - the superior recall performance evidenced for items presented at the beginning and end of a string of to-be-remembered stimuli. All theoretical accounts of STM function are therefore tasked with satisfactory explanation of these ubiquitous findings. Of the two, recency has arguably proved to be the more important because, as will be seen in the ensuing sections, it occupies a central position in the controversy over the possible identification of a short-term store. Likewise this investigation will pay particular attention to recency findings. To begin with however, a selective account of important early research will be given in order to provide the necessary background to the discussion of the major theoretical positions.

1 : 4 BACKGROUND

1:4:1 Short-term Memory - The Starting Point

Research into short-term memory has witnessed a tremendous expansion during the last 20 or so years. A complete account of all this work however is manifestly beyond the scope of this investigation. Instead, a selective account of particular memory phenomena, and the major theoretical developments these have inspired will be attempted. Two particular notions are central to what will be discussed : (i) that memory is limited and (ii) that recall of a series of items beyond this limit produces a remarkably consistent function.

While it had been observed previously (eg James, 1890) that there were certain limitations on aspects of memory function, it is probably true to say that the watershed for modern investigations can be traced to two investigations published in the late fifties by Brown (1958) and Peterson and Peterson (1959). In a task which has since been referred to as the Brown-Peterson paradigm these researchers demonstrated independently that a single three-letter syllable (ie well within the memory span reported by Millar 1956) is subject to considerable forgetting if followed by only seconds of a rehearsal - preventing activity. Indeed performance was observed to drop to around 10% correct recall after 18 seconds of mental arithmetic. These experiments marked a point of departure from the traditional associationist approach which had been current up until that time, and their results provided a new challenge by appearing to demonstrate that decay rather than interference was responsible for the massive amount of forgetting which took place. The consequence of these provocative new findings was that questions were posed regarding how many memory systems were involved.

1:4:2 The Unitary View

In an influential paper by Melton (1963) the argument was advanced that while the recent results on short-term memory function appeared inexplicable in terms of interference theory, there was still a case for functional continuity between short- and long-term memory situations. This case was made on the basis that a large number of experimental variables appeared to have similar effects upon both types of task. It was not long however before investigations were conducted which challenged the unitary approach by demonstrating that variables could be shown to have different effects upon particular components within short-term memory tasks. While this evidence began to accumulate from a variety of situations, arguably the most influential and widely used technique was that of free recall. For these reasons and the particular relevance of the paradigm to the research to be reported here, the free recall task and the major findings to have emerged from its use will now be discussed in greater detail.

1:4:3 Free Recall and the case for Functional Dissociation

Typically in the free recall paradigm subjects are presented with a list of items (generally beyond span limitations) and asked to recall as much as they can, in any order, when presentation ceases. After a series of such lists subjects' recall scores are plotted as a function of input position within the list. The resultant serial position curve which emerges from this analysis assumes a pronounced and consistent bow shape. Items at the beginning of a list tend to be well recalled (the primary effect) relative to the middle of the list, while items at the end of the list are recalled best of all (the recency effect). These two phenomena, and especially the recency effect, have been central to much recent theorising and as such will be the focus of attention here. While the bow-shaped function had been known to exist for some time, it was not until the mid sixties that increased interest in the finding was generated. In particular a growing number of experiments began to demonstrate that most variables had their effect upon the early part of curve (primacy plus the middle portion) while recency was left unaffected.

An impressive list of such variables fell into this category (see Glanzer 1972 for a comprehensive account) and the important common link between them was that all were known to affect long-term retention. For example Murdock (1962) showed that both increasing the list length from ten to forty items, and increasing the presentation rate from 2 seconds per item to 1 second per item lowered recall performance for early and mid-list positions. Neither variable had any appreciable effect on the recency portion. The replicability of these findings have been amply documented, notably by Postman and Phillips (1965) for list length and Glanzer and Cunitz (1966) in the case of presentation

rate. In addition studies by Sumbly (1963) and Raymond (1969) have indicated that this same early part of the function shows improved performance when the stimulus material is composed of high frequency as opposed to low frequency words, but recency is insensitive to such changes. Thurm and Glanzer (1971) used a similar paradigm to investigate the known improvement in children's memory abilities which comes with increasing age.

They examined the free recall performance of five and six year olds on 6 and 7 item series made up of pictures of familiar objects. In agreement with the above studies they found that the expected superior performance of the six year olds was confined to the early part of the serial position function. At the other end of the continuum the comparable study investigating the deterioration in memory performance in the elderly has been conducted by Craik (1968). This too shows no difference in recency performance, but substantial differences in recall of early and mid-list items. The list of variables which display this asymmetric effect is now impressive and includes the language in which the material is presented (Tulving and Colotla 1970); whether the items are repeated during presentation (Glanzer and Meinzer 1967); the number of syllables each word contains (Craik 1968); the mnemonic ability of the subjects (Raymond 1969); and even intelligence (Ellis 1970).

The one notable exception to this pattern of results comes from studies which have employed delayed recall procedures. Thus both Postman and Phillips (1965) and Glanzer and Cunitz (1966) demonstrated that when recall is prevented for a matter of seconds by a backward counting task the recency peak is eliminated and performance drops to the same level as that for mid-list items. Indeed Gardiner, Thompson and Maskarinec (1974) have shown that if the interpolated task is difficult and long enough, recency performance is actually worse than that for earlier items. Performance on the early part of the list however does not change fundamentally from immediate to delayed recall. The crucial factor in eliminating recency superiority appears to be in preventing the subject from immediately outputting the terminal items by engaging him in some other form of 'mental activity'. This interpolated task can take virtually any form from the 'irrelevant' counting task employed in most of the above studies to the 'relevant' activity of recalling earlier list items (Tulving and Arbuckle 1966). Merely delaying recall without involving the subject in some other demanding task leaves the recency effect unimpaired (Glanzer, Gianutsos and Dubin 1969).

There is therefore a substantial body of evidence which appears to indicate that variables affecting the prerecency portion of the serial position function leave recency intact, while the one variable which does impair performance on terminal items dramatically (prevention of immediate recall by interpolated activity) shows earlier items relatively impervious to such manipulation.

While the free recall task has been singled out as being a particularly good experimental paradigm for illustrating the apparent asymmetric effects of task variables on task sub-components, other situations have pointed towards a similar distinction. Examples of these would include the serial probe task (Baddeley, 1968); short-term paired associate learning (Peterson, 1966); and even work carried out on amnesic patients showing specific deficits (see Baddeley, 1976).

It is clear that the combined weight of all this evidence makes it virtually impossible to maintain that one common theoretical mechanism is responsible for all aspects of performance in short-term memory tasks. An unitary view of memory of the kind proposed by Melton (1963) therefore seemed untenable in the circumstances. The nature of the main types of model which were advanced subsequently to account for results of this kind will now be considered.

While it is both typical and healthy for scientific opinion to differ, it is somewhat surprising in view of the vast number of studies now conducted in this area (and on the above phenomena) that there is still widespread disagreement over suitable theoretical explanations. For example, a Publication by Norman in 1970 reveals almost as many different models as contributors to the book. In addition the field abounds with examples of researchers being forced to change their theoretical positions in the light of fresh evidence (eg Baddeley ^{and Patterson 1971} versus Baddeley and Hitch 1974; Craik 1968; 1971 versus Craik and Lockhart 1972; Wickelgren 1970 versus Wickelgren 1973). That such shifts still do not reveal evidence of convergence upon a single theory is illustrative of the complexities of the issues involved (or perhaps the difficulties in arriving at definitive experimentation). A complete review of all these theoretical approaches will not be attempted here. Instead examples will be chosen to illustrate three broad classes of model which can be identified. In particular, attention will be focussed on how these major positions differ with regard to their treatment of recency. The three classes of model can be summarised very briefly as follows :

- (i) Theories which interpret the results as evidence of separate stores,
- (ii) Theories which view retention as a direct function of the type of processing operations carried out on the stimuli, and
- (iii) Theories which view recency as reflecting the operation of particular retrieval strategies.

1:5:1 The Modal Model

The first major class of theory which was the most commonly agreed view of memory functions when this research was initiated has been labelled the 'modal model' by Murdock (1971). The name is essentially a collective description of a group of theories, which although differing in detail from each other, all subscribe to the belief that memory functions can be characterised adequately on the basis of three basic components. Furthermore these theories actually identify these components as three separate stores, each with its own properties. These are the sensory, short-term and long-term stores respectively, although treatment of the sensory stage is ignored for the most part. The names primary and secondary (after James 1890) are used alternatively to refer to the second and third stages respectively by some models (e.g. Waugh and Norman 1965; Craik 1969; 1971), although this difference is essentially terminological. The description short-term memory on the other hand is used typically to describe the experimental situation in which these stages (i.e. both short- and long-term stores) may be studied. Because these theories acknowledge the necessity for sensory storage but are concerned mainly with the later stores they are frequently referred to as dichotomous or 2-store models.

1:5:1:1 The Waugh and Norman Theory

While the development of information-processing models of mental operations with particular reference to attention and memory can be traced to the writings of Broadbent (1958) the first authoritative version dealing exclusively with memory can be said to be that of Waugh and Norman (1965). Based on the results of a series of experiments which employed a serial probe technique these authors proposed a system which included two principal components : a limited capacity mechanism (primary memory) and an unlimited capacity mechanism (secondary memory). Stimulus material which has been attended to, first enters primary memory from which some information can be lost. The limited capacity of this mechanism further requires that after a certain number of items, any new stimulus will displace an old item currently being held. Rehearsal however can not only prevent displacement by new items and maintain items in primary memory but can cause transfer to secondary memory. One of the features of this model therefore is that at the time of recall information about a particular item can be retrieved from primary memory, secondary memory, or both.

The other important contribution of the model is the direct measurement of primary memory (PM) capacity. The method is essentially one of subtraction based on the assumption that the two sources of information combine independently. Waugh and Norman's (1965) experiments with the probe technique had included instructions not to rehearse the material on the assumption that this should leave the results free of the secondary memory (SM) contribution. The results in fact did show a zero asymptote after a large number of intervening items between input and probe and this was taken as confirmation that the no-rehearsal instruction had had the desired effect. The derived numerical estimates of PM capacity were then compared with values obtained from other experiments including free recall (where the SM contribution is calculated on the basis of the asymptote) and good general agreement was obtained.

Such a model therefore appears to make good contact with the data from a variety of experiments. With particular reference to the free recall paradigm, the apparent invariance of the recency effect in immediate recall is viewed as the product of the fixed capacity primary memory mechanism. During delayed recall however performance will be likely to reflect only the secondary memory component.

1:5:1:2 The Atkinson and Shiffrin Theory

It is probably true to say that the most influential model in the field of memory research has been that proposed by Atkinson and Shiffrin (1968). This undoubtedly stems from the fact that it remains the most explicit and comprehensive account yet advanced, and moreover has been extremely successful in accommodating a large body of experimental evidence. The formulation comprises both structural features and control processes but these are documented in greater detail than the Waugh and Norman (1965) model. The structural aspects are represented by a series of stores, each with different functions and properties. The first of these consists of peripheral sensory registers which possess the characteristics of iconic and echoic stores and from which information loss is extremely rapid unless selected for further processing. Next is the short-term store (STS) where information is pushed out by the displacement principle and decays in the order of seconds. Lastly there is the long-term store (LTS) where information is relatively permanent. The control processes on the other hand (which include rehearsal, coding, decisions and retrieval plans) permit the active selection of particular items and the application of chosen processing strategies. From this it is clear that there is a considerable degree of voluntary control intrinsic to the model which operates within the limits laid down by the structural constraints.

Information from the modality-specific sensory buffers is read selectively into STS which clearly plays a central executive role in

directing the information flow into, and retrieving it from LTS. This is most clearly illustrated in Atkinson and Shiffrin (1971) where the control processes are pictured as residing within STS. Of these, one of the most crucial is that of rehearsal. Indeed the importance attached to this function by Atkinson and Shiffrin can be judged by their formulation of a specific rehearsal buffer version of their general model. Two basic roles are assigned to the rehearsal process. The first is a simple maintenance function to preserve the item(s) from decay in a rote repetition manner, while the second is viewed as a state of access which is coupled with a search for a more durable encoding such as a higher-order association. Transfer of information to LTS occurs automatically in the sense that it is part of the fixed features of the system. The nature of the transfer however is under active control and could occur as a consequence of one of two ways noted above. The first is via the mechanical repetition of items which is a relatively slow process but has the complementary advantage of keeping a number of items available at any one time for immediate recall. The second is by way of more elaborate encoding operations which, while effecting more durable long-term representation of any stimulus, have the consequence that only that item is immediately available as attention has been diverted from the rehearsal of other events. The rehearsal buffer model was developed specifically to cover certain short-term memory situations such as continuous paired-associate learning where it is assumed that elaborative encoding is undesirable. As such it is concerned primarily with the rote repetition function of the mechanism.

The buffer itself is of fixed capacity and therefore, like the primary memory mechanism of Waugh and Norman (1965), operates a displacement principle when new information is entered. The short-term store however is considered distinct from the rehearsal mechanism. This is illustrated by the fact that any item currently in the buffer at the time of testing is recalled perfectly, but so too is any item with a zero lag between presentation and test, even if it does not occupy space in the rehearsal system. Further differences between this formulation and the Waugh and Norman (1965) account are illustrated by the fact that Atkinson and Shiffrin (1968) stress differences in processing capacity rather than storage capacity. This follows from the discussion of coding operations above where complex strategies are viewed clearly as being more demanding.

While the buffer model is remarkably successful in the context of the continuous paired-associate paradigm for which it was developed, the role of rehearsal in the process of transfer to LTS receives considerable additional support from a series of experiments by Rundus (Rundus and Atkinson 1970; Rundus 1971). Using a procedure which recorded subjects' overt rehearsals during presentation of a free recall memory list, Rundus found that the number of rehearsals was a decreasing function of the item's input serial

position. Furthermore this function correlates particularly well with the long term retention of the list (i.e. after delayed recall or a large number of intervening events). This is especially true if one considers data from experiments where the distractor activity was particularly long and difficult and where the 'asymptotic' region of the curve does not remain flat but continues to tail off through the terminal items. Thus the model is supported by empirical evidence which shows long-term recall to be linked directly to the number of rehearsals, or residence in the buffer mechanism. Immediate recall on the other hand is viewed by the dumping of those items currently in the mechanism at the time of testing.

On this last point however one minor inconsistency is apparent in the otherwise supportive nature of Rundus' (1971) data, and is typically overlooked. This concerns the extent to which it can be assumed that recency reflects output from the rehearsal buffer. If, as Rundus has shown from the rehearsal protocols, earlier items are still being rehearsed when later items are being presented, then the buffer may only contain the last item (of the critical terminal group) at the time of recall. In other words the terminal items which make up the recency effect may not in fact be resident in the rehearsal mechanism when recall begins as the system is still biasing its operation towards recirculating earlier items.

This brief account of the Atkinson and Shiffrin model has emphasised the main aspects of the theory. As such it does not do full justice to the complexity of their formulations (e.g. see Crowder 1976 for a more detailed exposition). This complexity however could be considered a drawback. For example the inclusion of additional control processes in order to accommodate new findings could quickly degenerate into a self-defeating exercise where virtually any result could be explained, but only at the cost of sacrificing both simplicity and understanding. This point has been made by others including Baddeley (1976) who suggests that the reason the model has not sunk into sterility is because concentration has been focussed on the role of the rehearsal process. This in itself was a courageous step as the topic had tended to be avoided previously, owing to its covert nature and the inherent difficulties in studying such a process. Apparently by requiring subjects to vocalise during acquisition the process could be examined and shown to produce quantifiable data to verify the theory. As will be shown later however the position was not to go unchallenged by others.

The remaining three accounts presented take up a similar dichotomous position in recognising a need to distinguish between a labile short-term store of limited capacity and a relatively stable long-term store of virtually unlimited capacity. They are less explicit in their treatment of the overall picture of memory function than either of the two information processing models

presented to date. However they are closely related, and indeed appear to offer further support for such a position by drawing on still more evidence which appears to differentiate the two hypothetical mechanisms. Of these the findings reported by Baddeley (1966a,b) represent the most valuable additional contribution.

1:5:1:3 Baddeley and Patterson (1971) and Differential Encoding

Early work by Conrad (1964); Conrad and Hull (1964); and Wickelgren (1965) had provided considerable evidence for acoustic coding in short-term memory tasks. This was argued primarily on the basis of the error scores which tended to be acoustic confusions and had maximum disruption effects upon the retention of order information (Wickelgren 1965). In a series of experiments Baddeley (1966a; 1966b) explored the relationship between acoustic and semantic similarity of task material as a function of immediate and delayed recall. In the first experiment the immediate recall of 5-word lists was tested. The stimuli were either acoustically similar, dissimilar controls, semantically similar or semantically dissimilar (Baddeley 1966a). The results were impressive and showed a dramatic drop in performance as a function of acoustic similarity (9.6% correct as opposed to 82.1% correct for comparable controls). The effect of semantic similarity while statistically significant was small (64.7% correct versus 71% correct for dissimilar controls). Moreover, by contrasting appropriate stimuli Baddeley was able to show that the effects were due to acoustic rather than visual similarity.

In the other study (Baddeley 1966b) the length of list was increased to 10 words and 20 seconds of interpolated material was inserted between presentation and test. The experiment was conducted as a list learning task and four trials were administered prior to final recall. The results showed that acoustic similarity had no effect upon the learning curves which could not be distinguished from equivalent control lists. Semantic similarity however was observed to impair the rate of learning. The conclusion drawn by Baddeley and Patterson (1971) on the basis of this evidence is that short-term aspects of memory are influenced by acoustic features while long-term aspects are influenced by semantic attributes. Further support for this distinction comes from paired-associate learning tasks (eg Baddeley and Dale 1966; Dale and Baddeley 1969).

One further aspect therefore appears to differentiate the two memory systems viz. the nature of the processing performed and the extent to which they appear to rely on fundamentally different coding operations.

1:5:1:4 Theories based on Free Recall (Craik 1968;1971; Glanzer 1972)

The last two accounts are included merely for completeness in this section as being typical examples of the views of a number of other researchers in the area. They are essentially derivative of the Waugh and Norman (1965) account noted earlier. Like Baddeley^{and Patterson} (1971) they do not so much present a complete theory of memory but rather a model which appears to do justice to a short-term memory task displaying two components. Unlike Baddeley they draw their evidence for this distinction almost exclusively from the free recall paradigm. This is particularly true of Glanzer (1972). As the evidence concerning this task has already been presented as an illustration of the growing number of findings which challenged the unitary position, it need not be repeated here. Suffice it to say that the recency peak is viewed as the product of the short-term store (or primary memory). The invariance of the effect highlights the limited capacity of the mechanism, while its susceptibility to disruption by delay indicates the short-term nature of its operation. Primacy and mid-list portions represent the output of the long-term store (or secondary memory) and this is supported by its stability after interpolated activity and the fact that it responds appropriately to all the variables known to affect long-term memory performance.

These accounts serve as illustrations of the major examples of the modal model. They differ in terminology and occasionally on some points of detail. Compare for example Craik's (1971) view of primary memory as being responsible for the free recall recency effect with that of Atkinson and Shiffrin (1968) which implicates a rehearsal buffer. Nevertheless the models display a considerable amount of agreement with respect to the assumed underlying mechanisms. To some extent this is to be expected. They are essentially all models born of the tradition begun by Broadbent (1958) which seeks to characterise mental operations by recourse to an information flow diagram. Despite the number of workers subscribing to this view the 'black box' approach has not been without its critics. Some of the major objections, both general and specific, will now be considered before presenting the second theoretical landmark is discussed.

1:5:1:5 Criticisms of the Modal Model

(1) Processes versus Stores: The first observation which can be made concerning all the theories noted above and other related accounts is a general one and refers to their identification of particular effects with actual structural stores. For example it is one thing to demonstrate that particular task variables interact with input serial position in the free recall task, but quite another to translate these phenomena into qualitatively different memory mechanisms possessing a rigid structure. The questionable

validity of this extension of the argument has been recorded by others, notably Wickelgren (1973) - himself a previous advocate of multiple stores - and Postman (1975). The latter's critique goes on to list three fundamental dangers inherent in such an approach. These are premature precision, internal fission, and proliferation (Postman 1975 p.308). An example of premature precision would be the attempts to derive numerical estimates for PM capacity. As Postman points out, the argument quickly becomes circular. The component becomes labelled a store, and the derived scores of its holding ability are calculated. These scores are then taken as justification for the existence of the store and no further effort is directed at examining the validity of the original formula. This is perhaps most evident in a formulation such as Murdock (1967) which is described in the next section. Internal fission is generated when new findings require to be accommodated. Here the tempting expedient is to add another arrow to the information flow chart, or an additional black box, or to subdivide existing boxes, without any necessary increase in understanding being achieved. Postman's final criticism is that of proliferation or modelling licence. As there are no ground rules for limiting the number of structures which can be postulated the models themselves become more complicated, while there is an accompanying tendency to create new ones for the results of every new paradigm investigated. The argument is a fairly cynical one and perhaps somewhat overstated. Nonetheless it serves as a timely reminder of some of the very real dangers which accompany such an approach by warning that one should not be seduced by the apparent tidiness of a series of boxes into thinking that true understanding of the processes has been achieved.

(ii) Difficulties with Capacity Estimates: Various methods have been employed to estimate the capacity of the short-term store and have been reviewed critically by Watkins (1974) and Crowder (1976). Laying aside for the moment the inherent circularity in the logic of such an exercise as noted above, there are two fundamental problems. The first concerns the discrepancy which arises from comparing estimates of PM capacity with the known limitations of memory span (c.f. Miller 1956). The second difficulty is that each of the methods used to calculate PM capacity can be criticised as being inadequate on one or more grounds.

Most of the estimates of the number of units which the short-term store can hold fall between about 2 and 3.5 items (Craik 1971; Watkins 1974; Glanzer and Razel (1974) in a review of 32 different experiments report a mean of 2.2 items. However such figures are immediately at variance with the traditional measure of 7 ± 2 items as derived from the memory span paradigm (Miller 1956). In order to account for these differences it has been suggested that performance in the span task is more highly correlated with the long-term component in

free recall (Craik 1971). Nonetheless it is still disquieting to encounter such discrepant estimates in two situations, both of which are claimed to reflect the limitations of short-term memory function. And in any case, if Craik's (1971) argument is accepted it implies that long-term memory is also severely limited.

There are basically four methods of estimating PM capacity. These will now be dealt with in turn. Firstly there is the original Waugh and Norman (1965) method. As noted earlier this relies on subtracting the contributions of the secondary memory component where this is derived from the asymptotic level of performance (in free recall the stable mid region). However one fundamental difficulty for this formula is posed by studies which show that long-term retention is not stable, but rather tails off for later list items (Craik 1970; Gardiner, Thompson and Maskarinec 1974). Thus any technique which assumes a stable asymptote will overcorrect progressively as it is applied to terminal items.

The method proposed by Raymond (1969) attempted to get round this problem by comparing the results of both immediate and delayed recall. In this way individual estimates of the long-term component for each input position could be obtained. The principal weakness of this technique derives from the fact that long and difficult distractor tasks produce vastly different effects from short and easy ones (c.f. Gardiner, Thompson and Maskarinec 1974). Estimates of PM capacity therefore can vary considerably, and even be shown to extend all the way back to early list positions - a result which appears to violate the limited capacity/displacement principle.

The third method can be attributed to Murdock (1967) and is based on his earlier observations (Murdock 1960) that the number of items recalled in single trial free recall is a linear function of the total list presentation time. The function is therefore described by the total presentation time and two constants which represent both the slope and intercept respectively. The method however can only be used when presentation time is variable, and only makes contact with the recency effect in an indirect fashion.

The final technique for estimating PM capacity comes from Tulving and Colotla (1970) and makes use of the fact that the recency effect is a product of recalling terminal items early during output. The method is extremely simple and merely requires taking account of those items for which no more than seven other items have intervened between presentation and recall. Moreover, Watkins' (1974) thorough evaluation of these methods appears to show that the Tulving and Colotla (1970) technique was more reliable than the other methods considered. However, there are three principle criticisms which can be levelled. The first is that in counting the number of intervening

events, the method assumes equal interference due to both input and output items, and there is some evidence to suggest that this is not necessarily the case (c.f. Tulving and Arbuckle 1966). The second major objection is that like some of the previous methods it simply cannot be applied to short lists. Finally, while it may prove to be fairly 'reliable' this must clearly be tempered with the realisation that the choice of seven items is clearly totally arbitrary, and any justification of this figure on empirical grounds becomes dangerously circular.

Problems therefore attach to all the capacity-estimate procedures. Despite these it must be acknowledged that there is fairly close agreement across the figures they tend to produce, with the notable exception which comes from comparing them with memory span limits.

(iii) Difficulties with Rehearsal and Transfer: To a greater or lesser degree the models presented assume that a major cause of transfer of information from the short-term to the long-term store is the rehearsal process i.e. the simple repetition of the items. Several pieces of evidence converge on the conclusion that this is likely to be an oversimplification.

For example when subjects are told to use imagery to connect pairs of items, long-term retention (as measured by the asymptotic method) is superior to those items which were only rote rehearsed (Smith, Barresi and Gross 1971). Estimates of primary memory however showed higher scores for the repetition rehearsal group than the imagery group. Such a finding poses problems for theories of the Waugh and Norman (1965) and Glanzer (1972) mould. It should be noted however that the Atkinson and Shiffrin (1968) account can handle such data without embarrassment.

Still more serious objections come from two studies which appear to show no direct relationship between the amount of time for which an item is rehearsed and its subsequent long-term retention. In the first of these, Craik and Watkins (1973) report two experiments which appear to support this conclusion. Experiment 1 required subjects to attend to lists of words where each word began with a different initial letter. They were told that words beginning with a particular letter were critical and that the last occurrence of such a word was to be reported at the end of each list. Following the presentation of several such lists, where the critical items had appeared in different positions, an unexpected recall test was administered to estimate the long-term retention of the target items. This recall was found not to vary as a function of the number of intervening items between critical words and the end of the list (the assumed rehearsal period). In their second experiment Craik and Watkins (1973) recorded the rehearsals of 2 groups of subjects during presentation of 12 word lists (cf Rundus 1971). Both groups were told to pay particular attention to the last four words, while one group

also received a period of 20 seconds unfilled delay following the presentation of each list. The instructional emphasis on the terminal items was reflected in additional rehearsals and this was particularly true of the unfilled delay group. Initial recall too was almost perfect for the last four items. An unexpected final recall test however administered at the end of the session displayed no related benefits and recall tended to decrease from first to last items. A similar pattern of results emerges from a study by Woodward, Bjork and Jongeward (1973) using a directed-forgetting paradigm. In this procedure a signal typically follows an item instructing the subject whether the item could be disregarded or was relevant to subsequent recall. In the Woodward et al study this signal followed the item at distances varying between 0 and 12 seconds. Again the assumption can be made that during this period the item is somehow 'maintained' until the information concerning its relevance to the task is presented. Once more an unexpected final recall test showed that there was no apparent advantage which accrued to those items which had been 'rehearsed' for longer periods of time; their long-term retention was not increased relative to words which were maintained for shorter durations. (It is interesting to note in passing however that increased rehearsal time did show improvements when recognition rather than retention was measured).

The studies by Craik and Watkins (1973) and Woodward, Bjork and Jongeward (1973) appear to indicate that there is one function of rehearsal which can be labelled 'maintenance rehearsal' which serves to keep an item in a state of immediate access for a given period but does not lead to its better long-term registration. This in turn suggests that something other than 'maintenance rehearsal' is required to lay down durable traces. This evidence is clearly at odds with the findings of Rundus (1971) which appeared to offer convincing correlations between the number of rehearsals afforded any item and its subsequent long-term retention. There are a number of differences between these situations which might affect some of the conclusions. These will be returned to later; for the moment the picture will be left as one identifying a feature of the rehearsal process (i.e. maintaining a state of immediate access) which does not appear to contribute to long-term recall. Such a statement obviously contradicts fundamental premises within the modal model concerning the mechanisms of transfer, and the importance of length of residence in the short-term store.

(iv) Concurrent Task Loading Experiments : Evidence which challenges the equation of recency in free recall with the operation of a short-term store comes from studies which employ a subsidiary task which has to be performed concurrently with the processing of the memory list. The logic of the situation is straightforward. If recency reflects the output of a limited capacity holding mechanism and this same store

is now required to perform additional operations, then recency should be severely impaired. That this is clearly not the case has been demonstrated, amongst others, by Baddeley and Hitch (1974). Their subjects were required to memorise a standard free recall list presented via one modality while performing a digit monitoring and copying task presented via the other modality. Three levels of storage load in the digit task were achieved by having the subject either copy down each digit as it was presented (storage load 1) or only after 3 digits had appeared (storage load 3) or forcing the subjects to wait until 6 digits had been presented before copying could begin (storage load 6). The result of particular interest to the present discussion was that the recency effect remains relatively intact even when the additional load is as great as six items - a figure twice as great as the estimates of STS capacity noted above. Similar results have been obtained by Murdock (1965) using card sorting as the subsidiary task and by Silverstein and Glanzer (1971) using mental arithmetic.

A somewhat different kind of subsidiary task was employed by Richardson and Baddeley (1975). Using a technique known as 'articulatory suppression' (Murray 1968) these authors required their subjects to repeat out loud sequences like 'the, the, the..' or the digits 1 to 6 as fast as possible during presentation of free recall lists. This procedure is assumed to pre-empt the use of any articulatory-based rehearsal mechanism. Again the result of interest to the current argument is that even under such conditions, the recency effect remains unimpaired.

Taken together therefore these results appear strong evidence against the recency effect being mediated by either a limited capacity system (eg Waugh and Norman 1965; Glanzer 1972) or some articulatory rehearsal mechanism (Atkinson and Shiffrin 1968).

(v) Long-Term Recency Effects: To date a considerable amount of the discussion has occurred on the recency effect and its relationship to the short-term store, and particularly upon questions regarding the latter's capacity. In contrast this section reviews experiments which appear to challenge the short-term aspects of this equation by demonstrating apparent long-term recency effects.

In 1973 Tzeng reported a free recall study which exhibited the traditional bow-shaped serial position function. The remarkable feature of this experiment however was that each word in the list was both preceded and followed by 20 seconds of backward counting task during presentation. It has already been demonstrated that when such activity is used as a post-list distractor task, short-term recency effects are eliminated (eg Postman and Phillips 1965; Glanzer and Cunitz 1966). The recency effect discovered by Tzeng (1973) can therefore only be considered as a long-term phenomenon. Nor is this the only study to have observed such an effect. Bjork and Whitten (1974) have replicated the result using

12 seconds of interpolated mental arithmetic between each of 13 pairs of words. These lists were either permitted immediate recall, or were followed by an additional 30 seconds of distractor activity. Under both these conditions recency was obtained, which although somewhat lower than that normally exhibited for lists where presentation is uninterrupted, was still substantial. Stated another way, the introduction of an irrelevant processing task between each list item seems to cancel out the normal deleterious effect of a post-list distractor.

If these findings are considered to be true recency phenomena then it is clear that their explanation cannot be based on any short-term holding mechanism as the contribution of such a mechanism would have been long since removed at the time of recall.

(vi) Recency Effects in the absence of List-Processing Strategies : The examples of recency noted above, while producing results which are awkward for the modal model to explain, have one feature in common. They all derive from experiments where the list in question was processed in the knowledge that a recall test would be administered following presentation. However, the literature contains a number of demonstrations of recency effects which occur in the absence of such knowledge, and therefore where it can be assumed that the material was not rehearsed cumulatively in the normal fashion.

For example, Baddeley and Hitch (1977) reported clear recency effects in studies of anagram solutions where each problem was presented as if it were a discrete trial event and subjects had no knowledge of a subsequent recall task. Furthermore, similar results were obtained when the problems were separated by periods of a digit-copying task, even when this activity was carried out for 30 seconds.

The reliability of these results appears to be confirmed by their appearance in a variety of other contexts such as the recall of rugby matches played by a team (Baddeley and Hitch 1977) and even in situations where the stimuli are not 'experienced events' but are nevertheless temporally organised as with the recall of the names of the Presidents of the United States (Roediger and Crowder 1976). It is also interesting to note in passing that the results of this latter study revealed a primacy effect as well as a recency effect.

This combination of apparently similar findings from both 'incidental' and 'experimental' situations must cast serious doubts on explanations based on rehearsal mechanisms (Atkinson and Shiffrin 1968) or short-term stores of limited capacity whose contents are assumed to be displaced after a few seconds of a backward counting task (eg Waugh and Norman 1965;

1:5:1:6 Concluding Remarks on the Modal Model

While there are other objections to the formulations of the dichotomous views of memory function presented, the foregoing comments represent a summary of the major criticisms. As can be seen, these range from questioning the interpretations placed on the data and whether it is justifiable to explain these in terms of rigid 'box mechanisms', through to operations which govern the flow of information from one box to another. By far the most common testbed for the theory has been the recency effect because of its crucial role in representing output from the short-term or primary memory store. This will continue to be the major focus of attention in the current investigation, for much the same set of reasons. Questions concerning the explanations of such effects and whether all the examples quoted (and others still to be reported) can be assumed to be the product of one common underlying mechanism, or whether different systems require to be postulated, will be addressed at appropriate points during the discussion. These considerations will also be borne in mind when evaluating the second major theoretical development to which attention will now be turned.

In response to some of the objections to the modal model noted in the previous section, Craik and Lockhart (1972) proposed what appeared to be a radical departure from previously held views. The impact of their approach is almost increased by the fact that it represents a change in loyalties of the principal advocate of the new position (c.f. Craik 1968; 1971).

In their original statement Craik and Lockhart (1972) were at pains to point out that they were illustrating 'an approach' rather than proffering a theory in its usual rigorous sense. While bearing this reservation in mind, later modifications (eg Craik and Tulving 1975) clearly indicate a continuing search for firm principles which might underpin the major concepts in some more formal fashion. These attempts therefore suggest that the label 'theory' is not altogether inappropriate. Furthermore, the necessity to evaluate any statement of position by assessing its descriptive and predictive value means that for all practical purposes it can be treated as such.

The major contribution of the Craik and Lockhart (1972) thesis was to shift the emphasis of explanation of short-term memory phenomena from one which implicated a number of different storage mechanisms to one which viewed retention as the product of the type of processing operations performed upon the stimuli. Moreover these different types of processing can be characterised by a continuum of depth, beginning with relatively shallow or superficial operations, through to deeper or more semantic forms of encoding. Stated in this way the approach has obvious sympathies with for example a stage analysis of perception (c.f. for example Selfridge and Neisser 1960; Sutherland 1968 or Treisman's 1964, theory of attention). In this way the different types of processing are viewed as further levels of analysis, and any trace deposited is a product of, and directly determined by, the nature of such analysis. In particular Craik, and Lockhart (1972) argue that trace persistence is a function of these operations with deeper analyses leading to more durable traces. One of the advantages of such an approach is that it is not restricted to handling purely verbal stimuli, but can easily be generalised to cover all modalities and to include visual imagery.

While the memory of a particular event or stimulus is considered to be the consequence of the analysis performed upon it, the trace can also be maintained in another way: namely by recirculating the material.

When information is rehearsed in this way a pure maintenance function is being carried out, thus keeping the products of whatever analysis was carried out in a state of easy access. This aspect of the model, which is referred to as Type 1 processing, has a lot in common with conceptualisations of Primary memory and conscious awareness (eg James 1890) and other forms of the modal model which implicate a rehearsal buffer (eg Atkinson and Shiffrin 1968). Type 11 processing on the other hand is distinguished from the above by referring to the deeper analysis of the stimuli during which it is assumed that more elaborate encoding of a semantic nature is performed.

To recapitulate the main features of the formulation, retention is seen as a direct consequence of the analysis performed upon the incoming stimuli, and such analyses can be viewed as a continuum of depth. A form of maintenance rehearsal can be adopted to keep the products of such analysis in a current and active state, but when attention is diverted from these to other activity their memorability will be related to the depth of encoding, with deeper semantic processing leading to the most durable traces.

1:5:2:1 The Evidence for a Levels Approach

Two principal sources of evidence can be identified as being central to the development and consolidation of the levels of processing formulation: (i) experiments using an incidental learning paradigm coupled with unexpected recall tests, and (ii) experiments demonstrating a maintenance function for rehearsal which did not lead to better long-term retention. These are dealt with more fully below.

(i) Types of Processing and Incidental Memory : The rationale behind the contribution of incidental learning studies to the levels approach is straightforward. Subjects are required to process a set of stimulus material in different ways and if these different 'orienting tasks' can later be shown to produce different levels of retention of the material, then it can be assumed that memory is the direct result of the form of processing conducted. This is essentially what a series of studies by Jenkins and his associates has shown (eg Hyde and Jenkins 1969; 1971; Johnson and Jenkins 1971; Till and Jenkins 1973). The study by Hyde and Jenkins (1969) can be taken as illustrative of the general method and the typical pattern of results obtained. In this experiment some seven groups of subjects were given different sets of instructions concerning the nature of the task and what they had to do. All seven groups however received the same list of 24 words and all were tested for their recall at the end of the session. Four groups were told to expect the recall test (the intentional learning groups), while the remaining three groups were not (the incidental learning groups).

Within each of the intentional and incidental groups, one group had to

rate the pleasantness of each item; one group was required to keep a running count of the number of occurrences of the letter 'e' which appeared; and one group was required to count the number of letters contained in each word. The remaining group in the intentional learning subjects acted as a control and was required merely to learn the items without any additional task. The results were quite dramatic. Firstly, the subjects instructed to learn the words had their performance impaired relative to controls by having to perform the subsidiary counting tasks. This of course could be predicted on the basis of other studies using concurrent loading (eg Murdock 1965; Silverstein and Glanzer 1971). This however was not true of the subjects who also rated the pleasantness of the words; if anything there was a slight tendency to recall better than control subjects. Turning to the incidental subjects, the most remarkable result was that the group which conducted the pleasantness rating recalled the words as well as their intentional counterparts. The remaining two incidental groups produced correspondingly poorer recall, although it was not dramatically below the equivalent intentional groups. Other experiments in the series have been conducted with a variety of orienting tasks such as generating rhymes to the stimuli; performing grammatical and syntactic judgments; checking the appropriateness of each word in a given sentence context, and so on. The common theme running through the results of all these studies is that any task which requires semantic processing to be performed will lead to recall which is vastly superior to those where only some more superficial form of processing is carried out on the material.

(ii) Maintenance Rehearsal versus Deeper Encoding: The second source of supportive evidence comes from experiments cited previously in the section dealing with results which posed difficulties for the transfer function of the modal model. These studies were principally those of Craik and Watkins (1973) and Woodward, Bjork and Jongeward (1973). As the experiments have already been reported in some detail, only the main conclusion need be restated here. This was that circumstances could be shown to exist where rehearsal could be assumed to be exerting a maintenance function (i.e. keeping certain items in a state of immediate access) but that regardless of how long this continued - within experimental limitations - there was no discernible improvement in retention when testing was conducted after some delay. To this result should be added the proviso that any second (delayed) recall test was not anticipated. This maintenance function of rehearsal (Type 1

processing) is deemed to be efficient providing that no distraction occurs, but is considered to be fundamentally different in character from what is necessary to produce a truly durable trace. The latter is assumed to require 'elaboration', in the semantic sense, whereby the meaning of the stimuli and associations to this are invoked (Type 11 processing).

Although the maintenance operation theoretically is capable of being conducted at any one of the hypothesised levels, the authors suggest that it is primarily at the phonological level that such recirculation occurs. Type 11 processing on the other hand is viewed as something quite different in character from sheer rote rehearsal. Rather it involves the processing of meaning and is therefore associated with much deeper, semantic and associative encodings. It is this latter function which is capable of forming the basis of durable memory which will transcend immediate task demands.

In such a way for example, Craik and Lockhart (1972) seek to explain the typical free recall result. It is postulated that the recency effect found in immediate recall is the product of the shallow (probably phonemic) type of encoding (Type I processing). Because the end of the list is anticipated imminently, holding the terminal items in this state of access is considered an appropriate strategy. Type II or semantic processing however is necessary for the early items as a longer lasting memory trace is required for them. Any unexpected recall test administered after the presentation of several such lists therefore will show that only those early items afforded Type II encoding will be likely to survive the longer delay (Craik 1970; although note that the explanation presented with this original finding was different, in that it subscribed to a dichotomous position). Some confirmation of the above explanation comes from a study on variable list length by Watkins and Watkins (1974). In their experiment one group of subjects was able to gauge how long each list was going to be by checking off boxes on a sheet provided where the number of boxes corresponded to the number of items within the lists. A second group of subjects performed the free recall task in ignorance of the list length on each trial. The hypothesis was that the subjects who were aware of the list length would be able to use this knowledge to employ only maintenance rehearsal for terminal items. Subjects who were not in a position to anticipate the end of each list however would still be likely to be using Type II processing when presentation ceased.

Results supported the hypothesis : Subjects with knowledge of list length showed better immediate recall recency, but poorer final recall recency than the no-knowledge controls. The Watkins and Watkins (1974) experiment therefore provides results which are compatible with the levels of processing account of recency by an indirect method i.e. examining how the subject might alter his strategy in the light of certain knowledge. Further supportive evidence for the view comes from studies which have directly manipulated the type of processing devoted to terminal items in free recall lists. For example Mazuryk (1974) used tonal cues during presentation to indicate that the last four items in a 16-item list were about to appear. One tone was the signal for subjects to rehearse the terminal items out loud; another tone required subjects to generate semantic associates to the words presented; while no tone meant they could continue with silent rehearsal. The results of an unexpected final recall test revealed that retention of those items to which associates had been generated was vastly superior to the other two conditions. The interpretation adopted was that any item (including terminal items) can be retained relatively well in the long term provided that they are somehow encoded semantically. One further result in Mazuryk's (1974) study is of interest. The immediate recall of last four items in the generate-associate condition was actually inferior to that produced by the other two processing conditions. This result, in conjunction with the data from final recall, can be taken as further evidence of the reciprocal relationship which Craik and Lockhart (1972) envisage exists between maintenance rehearsal and deeper forms of encoding. That is to say that the number of items which can be maintained is inversely related to the depth to which each item is processed. Therefore a greater number of items could be maintained if a strategy to maximise immediate recall of terminal items was adopted, but this in turn would not prove beneficial to long-term retention. Once again the emphasis is seen to be placed on qualitative aspects of the encoding operations rather than on quantitative ones (cf Rundus 1971).

1:5:2:2 Recent Modifications to the Original Theory

Further experiments within the general framework have since been conducted to probe the validity of the formulation by seeking confirmation and extension of the basic principles (e.g. Craik and Tulving 1975; Lockhart, Craik and Jacoby 1975). These investigations have led to several modifications of the original Craik and Lockhart (1972) position. These can be summarised briefly as follows :

(i) Encoding Domains: Lockhart, Craik and Jacoby (1975) suggested that the concept of a continuum of depth was probably incorrect if this was viewed as a rigid hierarchy of levels through which information passes in serial fashion. In other words the original view that material is processed through a series of stages in turn, from structural to semantic, and that this operation only ceases when analysis relevant to the task in hand is accomplished, is now considered inappropriate. The same conclusion can be drawn from the results of Craik and Tulving (1975) where it was found that, contrary to earlier expectations, the time taken to process a stimulus item did not appear to be correlated with its later retention. Instead therefore Lockhart et al (1975) propose that the label "domains" of encoding be substituted (after Sutherland 1968) to reflect this looser structure. Evidently the notion of a hierarchy is still apparent in that operations begin at a shallow level before proceeding further. However, a full scale structural analysis need not be completed for example if a stimulus is highly predictable at the semantic level.

(ii) Compatibility of Encoding: In a series of ten experiments Craik and Tulving (1975) found several results which necessitated some modification of the original proposition. One of these, which was replicated consistently, concerned the fact that items which received a positive response at the time of encoding, were recalled better than those which had been attached to a negative response. The context was a task which required subjects to respond "Yes" or "No" to a question concerning the stimulus word. The questions ranged from ones referring to the physical appearance of the word (e.g. "Is the word in capital letters?") to considerations of its meaning (e.g. "Is the word an animal name?"). As reaction times were typically equivalent for both responses the subsequent higher retention of words associated with "Yes" responses was considered a genuine result. (In fact it had previously been demonstrated by Schulman 1971). Craik and Tulving (1975) chose to explain this finding as a 'compatibility effect'. The explanation is similar to Schulman's (1974) 'congruity principle' and claims that memory is enhanced when the encoding question forms an integrated unit with the stimulus item. Such a congruous encoding not only lays down a more coherent trace, but also is easier to retrieve because of this.

(iii) Encoding Elaboration : Finally Craik and Tulving (1975) proposed that the degree of encoding elaboration was a more apt description than the earlier concept of differential depth. This emerged from two results in the series of experiments. The first,

as has already been noted, showed that processing time per se was not a good predictor of later retention. The second result was that large differences in recall were found between words coupled to a phonemic coding task and words coupled to a semantic coding task even when all words were presented for 5 seconds and when a recall task was anticipated (Craik and Tulving 1975, Experiments 4 & 5). Under the original Craik and Lockhart (1972) formulation both the length of the presentation and the knowledge of the retention test should have produced equivalent recall regardless of any ancilliary task during presentation. In order to accommodate these findings Craik and Tulving (1975) proposed that it is the degree of encoding elaboration which is the crucial factor in determining recall.

The view of memory function proposed by Craik and Lockhart (1972) is intuitively extremely appealing: At first sight it appears to offer a model to account for such findings as why more meaningful events are remembered better. Furthermore, it seems to encompass a variety of findings without apparently falling foul of the difficulties which appear to plague the more rigid mechanistic concepts involved in the variants of the modal model presented earlier. Two major aspects of the formulation will be dealt with in the following section: Firstly, whether the theory does represent as radical a departure from existing accounts will be examined; and secondly, whether in its original form (Craik and Lockhart 1972) or its more recent modified version (Craik and Tulving 1975) the theory continues to be a framework capable of both descriptive and predictive power.

1:5:2:3 Criticisms of the Levels of Processing Approach

(i) Stores versus Levels : The first question to be addressed under this heading is just how different is the levels approach from existing theories? On the one hand the notion of stores possessing a fixed capacity such as primary memory (cf Waugh and Norman 1965) does seem to have been dispensed with. On the other hand it could be argued (e.g. Postman 1975) that the label 'stores' has been merely replaced by that of 'levels' without any other fundamental change taking place. There are at least two main reasons for this possible criticism. In the first place, the original Craik and Lockhart account proposed a hierarchical arrangement for the concept of levels through which information has to proceed in a serial manner. The only difference therefore between this and previous explanations was that Craik and Lockhart did not wish to claim that any of these levels was subject to capacity limitations. The second reason is that although a number of

levels were postulated implicitly, in practice the continuum from shallow to deep encoding has reduced to a distinction between phonemic/acoustic and semantic processing. No concerted effort appears to have been directed at distinguishing differences within, for example, the semantic domain. Where such has been attempted the results have proved disappointing (e.g. Craik and Tulving 1975, Experiment 1). The levels view therefore is arguably indistinguishable from a dichotomous position based on apparent coding differences between the two hypothetical systems and as such is fairly close to other statements of opinion (e.g. Baddeley 1972).

The point is emphasised further by comparing Craik's own explanations of the negative recency finding (Craik 1970) i.e. the fact that when subjects are given an unexpected recall test following a series of single trial free recall lists, they tend to recall worst those items which were recalled best in the immediate test. Craik's (1970) original explanation of this finding was in terms of a two store view i.e. words only held in primary memory for a short space of time, while being highly available for an immediate test, had not received any further processing to render them as durable as early items. As this was shown subsequently to be correlated with rehearsals (Rundus 1971) then it could be argued that the original explanation has as much justification as the levels account advanced subsequently. Indeed, choice between the two theoretical positions might then be more a matter of personal taste, rather than being based on definitive empirical evidence.

In addition, the reciprocity of maintenance versus elaborative rehearsal has been included in previous formulations. This relationship specifies that several items can be preserved in a state of immediate access without any real contribution to their long-term retention being achieved, while a smaller number of items can only be dealt with if processing to a deeper and consequently more durable level is to be accomplished (e.g. Mazurk 1974). It will be recalled that such an arrangement was an integral feature of the Atkinson and Shiffrin (1968) model.

If anything therefore, the levels approach may have tended to shift the limitations of memory function from considerations of storage capacity to those of processing, but in many other respects the supposedly different accounts appear remarkably similar. Moreover it could be stated that in still admitting to limitations of some sort but being unwilling to quantify them then new model is arguably less precise than previous formulations.

(ii) Difficulties with a Taxonomy of Encoding Operations and Identifying an Index of Depth: One troublesome feature of the incidental learning experiments upon whose evidence Craik and Lockhart (1972) depend so heavily, is the apparent arbitrariness of their choice of orienting tasks. Typically for example, in the experiments by Jenkins and his associates cited earlier, tasks such as counting the number of letters; checking for certain target letters; or evoking rhymes to task stimuli have been categorised as 'nonsemantic'. However, these experimenters also claim that grammatical-decision tasks such as identifying the part of speech, or checking the appropriateness of a particular word in a given sentence context are also examples of nonsemantic activity. The dangers of the lack of a definitive taxonomy of encoding operations are illustrated poignantly when one notes that both Mandler and Worden (1973) using the syntactic judgment task of noun versus verb, and Craik and Tulving (1975) in employing the sentence context test, do so on the assumption that these activities represent semantic processing. There is therefore the temptation to criticise the fact that the determination of which task represents what kind of processing activity appears to be left virtually to the personal choice of the experimenter concerned, with the confusing consequences noted above. Furthermore, given this state of disorder, the experiments are open to the objection that the labelling of processing tasks into semantic and nonsemantic categories might just as easily have been accomplished in a post hoc manner.

Craik and Tulving (1975) in fact were well aware of this problem, and attempted to find more substantive evidence of an independent index of depth which would underpin the concept, and thus prevent criticisms of the inherent circularity. The basis for their search was the intuitively reasonable hypothesis that deeper forms of processing would take longer to accomplish than more superficial ones. While this appeared to be borne out in their early experiments, it was not found to be the case when a complex shallow task was compared with a simple semantic task. Thus Craik and Tulving (1975, Experiment 5) showed that a task which required subjects to determine whether a word could be characterised as a particular pattern of consonants and vowels (e.g. CCVVC) took considerably longer (approximately double) than one which required them to judge the appropriateness of the word in a given sentence context. However recognition performance was vastly superior in the latter case. The conclusion which has to be drawn therefore is that processing time per se is not a good predictor of subsequent retention, and by implication, neither is it an adequate measure of depth. As no other option seems to be forthcoming, the problem of providing such an independent index remains for the moment apparently intractable.

(iii) Further Problems with the Incidental Learning Studies : Postman (1975) in a thoughtful critique of the levels of processing approach takes issue with a number of features in the incidental learning studies. Firstly, as he points out, there may be differences between the orienting tasks other than the assumed semantic/nonsemantic distinction. For example the nonsemantic task of counting the number of letters a word contains involves a quantifiable amount of information whereas the semantic task of judging its pleasantness does not. If, on this sort of argument therefore, the former was considered a more demanding activity then there are other grounds for explaining the lower recall for these items (e.g. Posner and Konick 1966; Posner and Rossman 1965). As Postman (1975) indicates the attribution of the results solely to the semantic/nonsemantic difference in this paradigm remains to be proven.

The second observation made by Postman (1975) concerns a comparison of retention performance in conditions where a semantic and a nonsemantic task were performed together with performance following a semantic task alone. Although there are trends showing the former to be poorer, this is not always statistically significant (Hyde and Jenkins 1969). Clearly this tends to conflict with a large body of ^{evidence on effects of} concurrent or subsidiary tasks on long-term learning (e.g. Murdock 1965; Silverstein and Glanzer 1971; Baddeley and Hitch 1974).

Finally Postman points to the somewhat suspicious finding that when subjects are asked to rate the pleasantness of a word (the semantic orienting task) long-term retention is unaffected by whether or not they were aware that recall would be tested (Hyde and Jenkins 1969). On an intuitive basis at least one might expect that there is more to memorising an item than merely rating its pleasantness. Even more surprising is that the same study shows that this result also holds true for conditions where non-semantic orienting tasks were employed. That this contradicts a substantial number of other findings where comparisons between intentional and incidental learning conditions are involved is evident from a review of the area by McLaughlin (1965).

(iv) Comments on the Maintenance Rehearsal Studies: While the Craik and Watkins (1973) and Woodward, Bjork and Jongeward (1973) studies cited earlier appear to offer convincing evidence of a maintenance-only function for rehearsal, it will be recalled that these results are in direct conflict with the data of Rundus (1971). (The Woodward et al (1973) study shows an effect of rehearsal on recognition but not on recall). Rundus' data however showed that the amount of rehearsal correlates extremely well with long-term retention, although it must be admitted that this comparison is across rather than within experiments (cf especially Rundus' rehearsal function with the final recall of Craik 1970). Moreover, Rundus' experiment

has not been the only one to demonstrate a relationship between the number of rehearsals and recall. For example, Mechanic (1964) showed just such a function using an incidental learning paradigm.

One aspect which may be important in resolving these discrepancies concerns the differences between the paradigms. Firstly, it should be noted that in only one of the above studies on maintenance rehearsal was the number of rehearsals actually recorded (Craik and Watkins 1973, Experiment 2). In the others it is merely time held in a state of immediate access which can be taken as the measurement. In addition, the Rundus (1971) experiment is the only study which remains relatively faithful to the original free recall format in that it leaves the subjects free to engage in whatever cumulative rehearsal pattern they may wish to adopt, unlike the Craik and Watkins experiment cited above which artificially splits the list. For these reasons therefore it would appear premature to dismiss the relationship between rehearsal and recall found in some studies.

(v) Elaboration Encoding : Finally one can consider the modifications made to the original levels of processing formulation following the work of Craik and Tulving (1975). Of these probably the most important is that of elaboration or 'spread' of encoding. This concept is introduced on the basis of the results of their Experiment 5 cited in some detail earlier. As will be recalled this experiment compared the retention of words which were given complex but shallow processing with those which were afforded brief semantic encoding. However, as all the words were exposed for 5 seconds it can be assumed that even those words associated with the structural task were processed to the level of their meaning. The persistent superior retention of the semantically-processed words under these conditions suggests that sheer meaning therefore is insufficient to explain the results. Thus the concept of depth, at least in its most simplistic form, has to give way to the elaborative encoding which is assumed to take place when words are processed with respect to appropriate contexts. Referring to this and the concept of compatibility necessary to account for the better retention of words given positive responses the authors say the following : "An integrated or congruous encoding thus yields better memory performance, first, because a more elaborate trace is laid down and, second, because richer encoding implies greater compatibility with the structure, rules, and organisation of semantic memory. This structure, in turn is drawn upon to facilitate retrieval processes" (Craik and Tulving 1975, pp 291-292). Cynics might be inclined to argue that the above, while couched in more elaborate terms, is not easily distinguishable from "meaningful things are well remembered" (Craik and Tulving 1975, p.290).

The levels of processing account attempts to explain observed differences in the memorability of items via broad principles which can be traced directly to the processing operations performed initially upon the material. There is considerable intuitive appeal in such a simple formulation, especially when it appears to avoid certain difficulties faced by the more mechanistic aspects of previous information-processing models. However a number of problems with the account can be identified.

One obvious question is whether the theory does in fact represent a fundamentally different approach or whether in practice it has little to distinguish it from a dichotomous view (especially in considering the results of free recall studies). Another difficulty relates to evidence which argues against information being processed serially through a number of different levels. Finally the search for some independent index of depth has been conducted so far with little obvious success. Without such a yardstick, the levels of processing theory is unable to counter a number of criticisms regarding circularity and post hoc rationalisation. Even recent modifications to the view to include the concepts of 'compatibility' and 'encoding elaboration', while offering more adequate descriptions of the data, seem equally limited in the heuristic sense.

1:5:3 Recent Theories of Recency

As will have become apparent from the foregoing discussions the recency phenomenon occupies a central position in many of the current theoretical controversies. In view of this, and the equally central position it occupies in this investigation, the final class of model to be evaluated concerns views which have been advanced to account almost exclusively for this effect. Because of their somewhat limited scope, most of the positions about to be reported can hardly be considered as major theories (with the possible exception of Baddeley and Hitch 1974). Their contribution however would not be insubstantial if they were found to produce a satisfactory explanation of this crucial and all-pervasive phenomenon.

1:5:3:1 Recency as a Retrieval Cue Strategy (Tulving 1968)

Although not so recent as the other accounts to be presented, Tulving's (1968) statement can be identified historically as the first of this genre of explanations of recency. Indeed many of the later ideas advanced owe much to his original theory, and are essentially derivative. The main thrust of Tulving's (1968) argument was that at the time of recall the subject exercises a retrieval strategy, within which two particular retrieval cues can be identified. The first of these is labelled temporal/phonemic to distinguish the bases on which it operates. Such a cue can only be applied successfully to very recent events. The second cue is semantic in origin and can be applied to events which occurred some time previously. In this way the free recall task is assumed to reflect the operation of both cues; the semantic cue is seen represented by the primary and mid-list items which shows itself to be fairly durable, while the recency effect represents application of a strategy which makes use of the temporal/phonemic cues available for terminal items.

1:5:3:2 An Ordinal Retrieval Strategy View of Recency (Baddeley and Hitch 1974; 1977)

In the first of two papers touching on this subject, Baddeley and Hitch (1974) were concerned primarily with establishing the case for a common working memory system across a range of tasks including verbal reasoning, prose comprehension and free recall. During the course of their investigations these authors found considerable evidence for a limited capacity 'work-space' operating in all the tasks studied. Furthermore this mechanism seemed capable of dividing its resources between storage and control processing demands. However it was concluded that this mechanism was not responsible for recency. Much of the evidence which forms the basis for this conclusion has been presented earlier. A brief recapitulation will therefore suffice here.

Essentially, the crucial study was one which involved the subjects in performing a digit retention task which had to be carried out simultaneously with the acquisition of a free recall list (Baddeley and Hitch 1974, Experiment 11). Varying the difficulty of the digit task had predictable effects upon the primacy and mid-list portions but even with an additional load of 6 digits, recency was virtually unimpaired. The result received further support from a number of other studies which produced the same pattern with card sorting as the subsidiary task (Murdock 1965; Baddeley, Scott, Drynan and Smith 1969; Bartz and Salehi 1970) or mental arithmetic (Silverstein and Glanzer 1971). From this it appears that the limited capacity system, which is engaged presumably in both handling the digit task and is involved in long-term learning, cannot also be held responsible for the recency effect. Furthermore, as the same result was obtained when the memory list was presented visually and the digit monitoring task auditorially it is not open to the objection that the terminal items were being preserved in some auditory buffer (e.g. Anderson and Craik 1974).

In their second paper Baddeley and Hitch (1977) went on to provide additional evidence of recency effects which were difficult to explain in terms of conventional notions of fixed capacity storage mechanisms. The results of three groups of experiments were reported. In the first of these an incidental learning paradigm was employed. The consistent demonstration of recency effects under such conditions makes it unlikely that the result is dependent upon the output of a rehearsal buffer (Atkinson and Shiffrin 1968) or a switch in processing strategy during presentation (Craik and Lockhart 1972). In incidental learning tasks the subject is never aware of the possibility of a recall test, and therefore has no need to attempt to learn the material. Furthermore, Baddeley and Hitch (1977) showed that the recency effect obtained under these conditions is not subject to spontaneous decay. This was demonstrated by the fact that recency survived a period of unfilled delay but was eliminated when 30 seconds of digit copying intervened prior to recall. It is also interesting to note that primacy was obtained in two of the three incidental studies reported, suggesting that rehearsal strategies may not be a prerequisite of this effect either.

The second set of experiments reported relied upon the work of Richardson and Baddeley (1975). These authors adopted the technique of 'articulatory suppression' (after Murray 1968) whereby subjects are required to repeat out loud some irrelevant phrase such as 'the, the, the...' or the digits 1 to 6, while simultaneously attempting to learn a list of memory items. The task is essentially a modified version of the subsidiary task

technique noted earlier, but one which is designed specifically to occupy any mechanism which is dependent upon articulatory/phonemic encoding. Any such system therefore, normally engaged in the acquisition of the memory material, will have its contribution to the latter drastically reduced. Once again the results showed impairment to the primacy and mid-list portions of the free recall function, but no equivalent damage to recency, thus permitting the conclusion that recency does not represent output from an articulatory buffer (Atkinson and Shiffrin 1968) or any phonemically-based system (cf Baddeley 1966).

In their final set of experiments Baddeley and Hitch (1977) presented evidence of certain long-term recency effects. The first of these came from a modified incidental learning task where the items (the solution of anagrams) were followed by periods of backward counting activity. The second was the recall of matches played by two local rugby teams. The finding of marked recency effects under both of these conditions seems convincing evidence that the phenomenon is not linked exclusively to any short-term mechanism.

On the basis of all this evidence, Baddeley and Hitch (1974; 1977) proposed that while there are clear indications of a short-term working memory system operating across a wide range of tasks, the recency effect is almost certainly not the product of such a system. Instead they argue that recency represents the adoption of a strategy which makes use of the ordinal cues present at the time of recall. As such it can operate upon any set, or sub-set of items, provided that they can be differentiated properly. The authors freely admit that their explanation as conceived thus far is tentative, but that some formulation along those lines is necessary to encompass the wide range of situations over which the effect appears to preside.

Baddeley (1976) went on to expand slightly upon the existing account. In particular he was concerned with explaining why, under conditions of delayed free recall, recency is not obtained when it is clear that the memory items and the interpolated task material can be readily differentiated from each other. The reason Baddeley (1976) suggests, is that the recency retrieval strategy is only likely to be applied in the absence of more efficient organisational strategies. It is thus conceived of as a fairly primitive retrieval option which will tend not to be found where more complex (e.g. semantic) organisation is present. Material where inter-item associations are minimal will tend therefore to be the most likely to produce recency effects.

The finding of long-term recency effects provides the basis for the view of recency advanced by Bjork and Whitten (1974). Like, for example, Baddeley and Hitch (1977) their account assumes that the process under investigation occurs during the retrieval stage. Unlike these other authors who base this conclusion upon findings from incidental learning tasks, Bjork and Whitten (1974) arrive at this observation by noting that recency does not obtain when testing is by recognition but does appear when recall is demanded.

The starting point for the series of experiments was a previous study (Whitten and Bjork 1972) which had been designed specifically to eliminate all serial position effects. The method chosen was straightforward and relied upon the use of a distractor activity presented both before and after each pair of words within the lists. The remarkable finding was that even under those conditions the typical shape of the free recall function was observed, exhibiting both primacy and recency components. In following up this result, Bjork and Whitten (1974) embarked on a series of experiments designed to explore whether this result could be attributed to any artefact contained in the original study. Their first experiment replicated the result, and furthermore showed that it was not the product of repetitions, tests or further rehearsal opportunities which were a feature of the earlier paradigm. In two further experiments Bjork and Whitten (1974) attempt to explore these results in greater detail. For example one study showed that recency was obtained when 12 seconds of distractor activity both preceded and followed each word pair during presentation, and was still present when the same list was followed by 30 seconds of mental arithmetic. An unexpected final recall session administered at the end of the session however revealed a fairly flat function suggesting to the authors that the 'immediate' recall results were not to be attributed to differential storage across serial positions, but were peculiar to retrieval operations. This appeared to be borne out by their third experiment where subjects tested by recognition (where it is assumed that the problems associated with retrieving the information are minimal) did not show any effect of input serial position. Finally, Bjork and Whitten (1974) reported that there appeared to be a recency effect for lists in final recall when words were scored as a function of input list, rather than the more typical scoring of serial position of items within lists.

From all of this evidence Bjork and Whitten (1974) concluded that the recency phenomenon is a retrieval-based effect which can be shown to operate on any well-ordered series of inputs when viewed from the point of recall.

Two pre-conditions of a well-ordered series are put forward by the authors. These are (i) That each input in the series must be discrete in that encoding and rehearsal activities should be focussed on only the current input at any point in time (This is somewhat similar to Baddeley's (1976) assumption that recency only applies to situations where inter-item associations are minimal); (ii) That the temporal separation between adjacent inputs to memory must be at least a certain fraction of the retention interval from presentation to recall of those inputs (Bjork and Whitten 1974, pp 184-185).

The model is illustrated neatly by Crowder (1976) using the spatial analogy of a moving train passing a series of telegraph poles. As each pole recedes into the distance it becomes progressively less distinct from its neighbours; on the other hand, at any one point in time, the last few poles can be distinguished fairly easily. The problem with the retrieval of memory items therefore becomes one of trace discriminability. The second condition laid down by Bjork and Whitten (1974) can be illustrated via the same analogy, (provided one imagines certain atypical irregularities in the positioning of telegraph poles). For example, in scanning backwards to pick out two particular poles it is quite clear that the further one is from them, the further apart they require to be from each other in order to be discriminated. Finally it is clear that the analogy can be extended to cover groups of items which are separated by some amount.

1:5:3:4 Positional Stimulus Distinctiveness (e.g. Murdock 1960; Bower 1971; Ebenholtz 1972)

Accounts which stress the distinctiveness of particular serial positions have been proposed before (eg Murdock 1960) and indeed have affinities with still earlier work (e.g. Von Restorff 1933). However, the basic notion has seen recent revived interest by both Bower (1971) and Ebenholtz (1972). The underlying premise of the theory states that serial position as a factor on its own can provide some contribution to the memorability of an event, and that early and late events in a series are capable of providing a greater contribution by virtue of the fact that they 'stand out' from the other items. As such, the theory is unique in this section in proposing one account which encompasses both primacy and recency effects within one explanation.

For example, Murdock's (1960) original paper drew comparisons between absolute judgment tasks (where subjects are required to apply consistent labels to values along some continuum) and the data from serial recall. Both types of task, argued Murdock (1960), show evidence of 'anchor effects'.

In a different paradigm Ebenholtz (1963) documented apparent proof of some tagging value which appeared to be associated with serial positions. Ebenholtz used a serial list task where later lists could be derived from earlier ones in one of two ways. In one condition the derived lists were made up partly of new 'filler' items, and partly of items from an earlier list now located at different serial positions. The critical condition however was constructed in the same way except that this time the 'old' items were presented in the same serial positions as they had occupied in the earlier list. The results showed that this latter condition produced superior recall, strongly suggesting that by preserving the serial position of the repeated (old) items, some additional benefit was achieved.

In a comprehensive survey of the serial position hypothesis Crowder (1976) notes that there are in fact several versions in the literature. One such proposition permits the transformation of the temporal relationship of the events into a spatial dimension. As Crowder (1976) points out, one of the implications of such a model is the potential advantage this affords by making the stimuli amenable to visual imagery techniques. One obvious extension of this argument is to assume that a series just presented can be accessed or recoded from either the beginning or the end. It is also interesting to note in passing that this is exactly the form of model proposed by certain researchers to account for results in a particular updating task (Monty 1968; Monty and Karsh 1969). In this task subjects were required to keep track of information which was updated randomly and frequently across a number of sources they were monitoring. Despite the fact that the choice of which source was updated on any given trial was random, the above authors suggested that the data were best accommodated by what they termed a 'mental window' hypothesis. This proposed that subjects imaged the sources internally at all times, and rehearsed the material beginning with the left-most source and continuing through to the right-hand one. While it is clear that the spatial layout of the sources in the array, and a natural reading stereotype are likely to have been determinants of this strategy in the task just described, a different situation might readily induce some other processing style.

There are numerous other illustrations of the now classic bowed serial position function. For example, concerning knowledge assumed to be held in permanent memory, Roediger and Crowder (1976) showed primacy and recency effects in the recall of the Presidents of the United States. In a totally different task Koriatic and Fischhoff (1974) measured reaction times to a question concerning which day of the week it was. Remarkably, times to respond were lower for days at the beginning and end of the week and slower for days in the middle. Examples such as these defy description in terms of differential processing or recall from a three word primary memory system.

Thus they speak to an explanation which favours the concept of an internalised dimension where endpoints serve as distinctive and lasting markers.

The treatment given here to the positional distinctiveness hypothesis has been necessarily brief (see Crowder 1976 for a more comprehensive survey). The examples cited however appear to provide fairly convincing evidence of a remarkably pervasive effect.

1:5:3:5 Recency as a Multiply-Determined Phenomenon (Craik and Jacoby 1975)

It is perhaps somewhat surprising in the light of the apparent variety of recency effects now evident in the literature that there have been few attempts to put forward a multiple model of the phenomenon. However, one such position has been advanced lately by Craik and Jacoby (1975). Unlike the previous theories encountered to date, Craik and Jacoby (1975) propose that recency could be the product of one of three possible operations : (i) the output of primary memory, which is conceived as containing those products of processing operations which are still within the span of conscious awareness, (ii) the result of a backward-scanning process which becomes less efficient as intervening events increase, (iii) the outcome of a reconstructive strategy whereby the subject uses retrieval information to guide him onto the appropriate event, but where such a process is likely to be served better by recent events.

The formulation is based on, and considered part of, the general memory system put forward by Lockhart, Craik and Jacoby (1975). In this view the ongoing processing activity conducted on any particular event - i.e. what is being attended to currently - is seen as residing within a primary memory mechanism. At any time this system can offload its contents to produce immediate recall recency, while equally obviously, the system would no longer be applicable if some intervening activity were performed (e.g. Glanzer and Cunitz 1966). When attention is diverted to some other activity, previously processed events are considered to be pushed down the line of episodic memory (after Tulving 1972). Recency effects however can still be obtained for events which are no longer within primary memory, but are still considered to be relatively recent events within episodic memory. To do this a backward-scanning search process is initiated, where increasing the number of intervening events begins to limit the efficiency of the operation. This stage has clear sympathies with the ordinal retrieval strategy proposed by Baddeley and Hitch (1974; 1976). Experiments cited in support of this phase include studies which appear to show that while diversion of attention from the memory material by distractor tasks can be shown to produce some forgetting, this may not necessarily be total (e.g. Reitman 1971; 1974).

These studies predominantly employed tone detection tasks as interpolated activity, and the suggestion is therefore advanced that where similarity between memory and distractor events is high maximum disruption will occur; wherever it is low there will be less impairment of the memory events. The final process postulated is designed to account for recency over longer delays (e.g. Bjork and Whitten 1972; ^{Bjork and Whitten} 1974; Tzeng 1973) where events are certainly not still in primary memory, and the number of intervening events seems too large for the backward scan process to handle with any efficiency. To explain these sorts of results Craik and Jacoby (1975) suggest that a process of guided reconstruction takes place. To quote the authors on this point '...when retrieval information is presented - either as a cue for recall, or the item itself for recognition - the system attempts to achieve a perceptual encoding of the type specified by the retrieval information. Formation of this percept is guided by processing rules in the cognitive structures, and also by feelings of partial recognition as the developing percept approximates the structure of the episodic trace.' (Craik and Jacoby 1975). Again using the terminology of Craik and Lockhart (1972) deeper (semantic) forms of information are likely to prove more effective in this operation. Evidence offered in support of this contention comes from experiments by Jacoby (1974). His subjects were required to attend to a continuous list of 80 items, and to make a decision about each word in the list. This decision involved saying whether a rhyming word, or a word from the same semantic category had occurred previously in the list. Results showed that this recognition task was affected slightly ^{by} the lag separating the word-pairs (0,3,6 or 12 intervening items) but that this did not appear to interact with the rhyme/semantic variable. However, during a later unexpected recall test, subjects were presented with the first member of a pair and asked to produce the second. Now the results showed a marked superiority for the recall of the semantically-related material, a finding which is interpreted as showing that a guided reconstruction process is operating, and that its efficiency is greatly enhanced by the more elaborate retrieval information associated with semantic types of processing.

Hence Craik and Jacoby (1975) regard three possible mechanisms as being responsible for recency effects. As such their model is unique within the context of such explanations.

1:5:3:6 Criticisms of the Recent Theories

The explanations advanced in the foregoing sections all represent fairly novel attempts to come to terms with the apparently increasing number of recency effects being found under conditions which virtually preclude previous explanations. However, a number of critical comments, of both

general and specific nature, can be levelled against some or all of the positions proposed. These are summarised briefly below.

(i) Do all Recency Effects Reflect the same Process? One general observation, pertinent to all but the Craik and Jacoby (1975) model, is whether in fact all the recency phenomena are the products of the same underlying mechanism. While the theories themselves tend to make this assumption, and the findings generally appear to be qualitatively very similar, clearly there are still some large discrepancies. Compare for example the levels of performance attained for terminal list items in a long-term recency experiment such as Tzeng (1973) or Bjork and Whitten (1974) with the typical immediate recall recency result. In the former case the recall of the last item is seldom higher than 60% while in the latter it is commonly in the region of 90% plus. In addition immediate recall recency depends critically upon conditions of output order which permit early recall of terminal items (Tulving and Arbuckle 1966) while the long-term effects appear less sensitive to such considerations (Bjork and Whitten 1974). (It should of course be noted in passing that the role of this variable has not been explored fully in the long-term context, and could even be advanced as a reason for the lowering of the level of the effect.)

Similar comments can be made concerning the inclusion of some of the more bizarre serial position effects to emerge from permanent memory experiments. One obvious example is the reaction time data to the question concerning which day of the week it was (Koriat and Fischhoff 1974). Exactly how faster reaction times to Fridays (or for that matter Sundays) can be encompassed within a theoretical framework which seeks to explain the retention of free recall lists is not immediately obvious.

It is of course for some of these reasons that Craik and Jacoby (1975) have proposed that recency is multiply-determined, although it should be noted that even their account would seem to have difficulty in handling the Koriat and Fischhoff (1974) data.

While the above comments apply fairly generally to most of the models, a number of specific points can be made concerning some of the detail of the individual accounts. These are illustrated below.

(ii) Ordinal Retrieval Strategies (Baddeley and Hitch 1974; 1977; Baddeley 1976) : Two brief comments can be made concerning this theory. These relate respectively to the inadmissibility of the rehearsal mechanism and semantic considerations in determining the recency effect.

Firstly, although their general model (Baddeley and Hitch 1974) includes a rehearsal loop which is extremely similar to the Atkinson and Shiffrin (1968) rehearsal buffer, these authors claim that this mechanism cannot be held responsible for any recency effect. The reasons for this of course come

partly from certain incidental learning studies which exhibit recency, (Baddeley and Hitch 1977) and partly from the articulatory suppression studies of Richardson and Baddeley (1975). In the latter a free recall paradigm was employed and recency was found to be unimpaired by overt vocalisations uttered during presentation of the list. However, it should be recalled that Rundus (1971) had shown previously that rehearsal of earlier items predominates even during presentation of terminal items. Thus, concurrent verbal activity may only be removing the advantage normally afforded earlier items. Primacy and mid-list retention is thereby reduced, but recency is left at its typical, minimally-rehearsed level. Therefore there was other evidence which could have predicted the Richardson and Baddeley (1975) result, although it must be said that the full implications of Rundus' data had never been appreciated in this context. More important than this however, is that while the combined weight of such evidence argues strongly against an explanation of free recall recency which is based upon the output of a rehearsal mechanism, (and of course the same applies to incidental tasks where it can be taken for granted that rehearsal plays no part), it should not be assumed that such a mechanism cannot produce recency in other experimental paradigms - for example one which did not show a rehearsal bias towards the beginning of the list. It may therefore be imprudent to place such a restriction upon the explanation and making this an integral feature of the model in the way that Baddeley and Hitch (1977) do.

The second point concerns the further development of the notion by Baddeley (1976). In this the author assumes that recency is a fairly primitive mechanism characteristic of peripheral stores and unlikely to be present where semantic or inter-item associations exist. While not enough evidence exists at present to refute such a statement, it does seem difficult to accept that the mere presence of semantically-related material (in for example a free recall context) would somehow eliminate a finding which has proved so highly replicable across a wide range of stimulus material.

(iii) Relative Temporal Discriminability (Bjork and Whitten 1974) : The Bjork and Whitten model is an extremely simple and attractive notion. Part of its appeal stems from the fact that in an uncomplicated fashion it apparently offers a parsimonious account of a wide variety of recency findings which are difficult to explain by limited capacity or short-term mechanisms. Furthermore, by not excluding semantic considerations like the Baddeley and Hitch (1977) theory it could perhaps account for still more recency findings as yet not empirically demonstrated. Two potential problems however should not go unnoticed.

The first of these is perhaps a minor one and concerns one aspect of the interpretation of the data from one experiment (Bjork and Whitten 1974; Experiment 3). On the basis of their results, the authors claim that recognition performance is not a function of input serial position, a factor which is taken as providing support for the claim that recency is purely a retrieval phenomenon. However close inspection of their recognition function reveals that with the exception of two positions (the 5th and the last) the data does in fact conform to a 'U' shape, albeit somewhat more shallow than is typical. Furthermore as only four lists per subject were tested in this way, it is conceivable that a certain amount of noise will exist in the data - perhaps sufficient to account for two rogue points. What this actually implies is less obvious but it is clear that the result requires replication, probably with a larger number of trials before the conclusion drawn by Bjork and Whitten (1974) can be made with confidence.

The second difficulty is potentially much more serious and concerns one of the preconditions of the model as laid down by Bjork and Whitten (1974). It is that each input in the series should be discrete in the sense that rehearsal should only be directed at that one event during presentation. Otherwise their conditions for recency do not apply. This prerequisite evidently excludes the possibility of cumulative rehearsal. As such it is in direct contrast to the evidence presented by Rundus (1971) concerning processing strategies during free recall. While it is true that terminal items are not rehearsed as often as early items, they are still implicated in the cumulative process in that they are rehearsed together with other items. It is possible therefore that the stipulation laid down by Bjork and Whitten (1974) seriously damages the chances of their theory serving as an explanation of the most typical recency finding of all : That found in immediate free recall. Furthermore, this would be the case for any other paradigm where items or groups of items are likely to be rehearsed in a cumulative manner. Thus while the supposed assumption of temporal coding late in a list sequence fits well with the properties of the model, contrary to the conclusion drawn by Crowder (1976) this does not imply that the theory can account for all known recency effects, as any evidence of cumulative rehearsal violates a fundamental precondition.

(iv) Positional Distinctiveness : The fundamental problem with this theory is that it appears to make poor contact with the rest of the literature on memory function and the processes involved. For example, lately much of the research into the latter has been directed at determining whether a particular finding can be attributed to one or more of three processing phases: (i) The acquisition phase where processes such as rehearsal and special coding operations are applied to incoming material, (ii) The

retention phase which refers to how well the material survives the passage of time and other activities performed in the interval, and (iii) The retrieval stage which governs the operations directed at gaining access to the stored material. This methodology, which has been termed a 'stage analysis' by Crowder (1976), is defensibly a very relevant pursuit since it can be assumed that information has to be both stored, held and retrieved.

In the case of the positional distinctiveness theory however, the explanation of serial position effects is couched in terms of some intrinsic property of scales and dimensions. It is therefore difficult to imagine exactly how this maps onto the terminology of the stage analysis described above.

The problem is illustrated in a series of experiments on what has become known as the 'conceptual position effect' (DeSoto and Bosley 1962; Pollio 1968; Pollio and Draper 1966). In this paradigm a series of paired-associates is constructed where there are a number of stimulus terms, but only a few response terms. These response terms are representative of some dimension such as beauty (e.g. beautiful, pretty, fair, homely, ugly) or temperature (e.g. cold, cool, mild, warm, hot). Under these conditions, learning is faster for pairs which include extremes of the dimensions as response terms (DeSoto and Bosley 1962) and similarly fewer errors are made to these pairs (Pollio 1968). The important point to be made is that nothing during presentation procedure was likely to favour those words pairs either on a temporal or a positional basis. It is therefore difficult to attribute the effects to any differential processing occurring during acquisition, or for that matter any temporal advantage afforded recent events which might assist retrieval. Questions relating to where and how the effects occur to produce the anchor effects of continua are therefore left unanswered. Similarly questions regarding the relation of these phenomena to the findings of list learning studies where one endpoint can be removed (elimination of recency) are not addressed. Does it for example mean that under certain circumstances, the distinctiveness of terminal items is blurred by subsequent activity, and therefore would a comparable loss of primacy be expected by preceding activity? It is clearly difficult to tie such disparate findings together and it must be remarked that the positional distinctiveness theory appears somewhat isolated from recent mainstream research on the attributes of cognitive functioning.

(v) A Multiple Model of Recency : Recognising a possible need to distinguish between some of the different examples of recency obtained, Craik and Jacoby (1975) have proposed that recency is multiply determined. While this overcomes a number of problems, certain observations can be made regarding the current formulation of this model.

Firstly, there is an apparent inconsistency between ideas contained within this model and the general levels of processing account (Craik and Lockhart 1972; Lockhart Craik and Jacoby 1975) of which it is assumed to be a component. For example it will be recalled from the earlier full treatment of the general 'levels' framework that a trade-off exists between maintenance rehearsal and processing to a deeper semantic level such that more items can be held if they are in the former state than the latter. Now however in a section also dealing explicitly with the limited capacity processing responsible for such processing it is claimed that 'The number of items held will depend on the depth at which the processor is operating...' and the statement goes on to say that '- more items can apparently be held at deeper levels' (Craik and Jacoby 1975, p.179). These two views are impossible to reconcile.

One important feature of the model is that events which are no longer within primary memory (conscious attention) can still exhibit recency effects owing to their relatively proximal position within episodic memory. This statement however does not explain why recency can be found in some situations where delay is involved but not in others. For example recency is eliminated if the distractor activity follows list presentation (Glanzer and Cunitz 1966), but is still present if the activity occurs between each stimulus item (Bjork and Whitten 1974). In both cases one can assume that terminal items are no longer in conscious awareness (primary memory) at the time of recall. However, the problem for the Craik and Jacoby (1975) theory is not how to explain why recency occurs in the Bjork and Whitten situation, but having done so, explain why it does not occur in the Glanzer and Cunitz study. This is not really considered and the account is, therefore unsatisfactory in this respect. Lest it is considered unfair to single out Craik and Jacoby (1975) on this point, it should be noted that it represents a problem for most models.

1:5:3:7 Concluding Remarks on the Recent Theories

This account of recent theories has been brief and selective. Many of the ideas advanced represent valid attempts to overcome the difficulties encountered by some of the earlier models. Many of the experiments have been conducted to bolster this position by seeking further evidence of recency phenomena which cannot easily be handled by rigid mechanisms. The majority of this work has been carried out during (and in some cases after) the conduct of the investigations to be reported in the later chapters. This is important, not only for the contributions the models make, but also because the work parallels the general approach adopted by the author, in rationale and frequently in method.

Quite apart from the specific criticisms noted against the individual theories advanced, one general question is pertinent to any of the models : whether all recency effects observed can be explained by one single mechanism or process. In the interests of parsimony, this would be a highly desirable situation. As noted only one of the accounts described chose to explain recency as the product of more than one mechanism. This question will represent a recurrent theme running through the course of the research to be reported here.

The preceding theoretical review identified three broad classes of model which have been proposed to account for the findings of STM experiments. Certain recurrent themes can be seen to be key issues in attempts to resolve points of conflict. Of these arguably the most important is the recency effect. Because recency has now been demonstrated in a variety of experimental tasks, this investigation will employ a number of different paradigms in order to examine particular questions relating to the effect. Although attention will be focussed primarily on recency because of its central role in current theoretical debate, it will be noted that considerations of primacy cannot be excluded totally from the discussion. To anticipate the course of the investigation, the following is a brief summary of the main topics to be addressed.

Firstly, as has been noted earlier, a considerable amount of research effort has been concentrated on ^{particular} tasks (such as free recall). However there is now abundant evidence that processing strategies are not constant across the to-be-remembered material in such paradigms. This is the case whether one considers the rehearsal data of Rundus (1971) or the switch in strategy postulated by Craik and Lockhart (1972). That is to say that while strategies appear to be constant across several lists during an experiment, the differential processing across items within any one list is likely to have a significant bearing upon the nature of the effects obtained and the conclusions which can be drawn. Chapter 2 therefore approaches the problem from another direction. It begins by examining the likely reasons for the differential processing of items in such cases, and on the basis of this, selects the running memory span paradigm of Pollack, Johnson and Knaff (1959) as offering a task where such effects should be minimal. Thus recall for terminal items (recency) can be examined in a task where it can be assumed that the processing devoted to each item is more or less constant. Recency effects obtained under such conditions are therefore defensibly of a 'purer' form than those obtained where rehearsal of non-terminal items is an integral part of acquisition. The results pose difficulties for various models. In the first place effects of presentation rate are found which argue against any rigid formulation of a short-term store which has a fixed capacity. On the other hand they suggest that where presentation rate is slow enough to permit cumulative rehearsal strategies the functions obtained will represent the output from the mechanism responsible for rehearsal. Together these findings tend to favour explanations couched in processing limitations rather than storage limitations, but it will be seen that probably more than one mechanism is required to account for all the data adequately.

The third chapter focusses on the influence of extraneous material, which is not required for recall, upon the retention of memory lists, as this has a crucial bearing upon the type of processing employed by the postulated memory systems in certain formulations. Despite substantial work in this area a number of inconsistencies remain. For example, the difficulty of the interpolated activity has been identified by some as being important to the removal of recency (Posner and Rossman 1965). On the other hand similarity between the memory and distractor material has been shown to have no greater effect than dissimilar materials (Glanzer, Koppenaal and Nelson 1972). This latter finding however seems at odds with a considerable body of early work conducted in the field of interference theory and so is presumably in need of replication before any real weight can be attached to its significance. Moreover, similarity figures very strongly in the Craik and Jacoby (1975) account, and is of crucial importance in the positional distinctiveness model in so far as it can be assumed that similar interpolated material would be more likely to blur the salience of the end-point anchors. To this end therefore both a conventional post-list delay task, and an unconventional pre-list 'distractor' are employed where the class of material is the same or different from the memory stimuli. The results tend to support previous studies which show little or no differential effect on the recency effect. However, when the distractor material is identical to the memory string it is found that recall of the primacy portion is enhanced. This finding occurs despite the fact that the distractor material required only to be classified but not memorised, and furthermore appears whether it follows or precedes the memory list. Such a finding is supportive of a stance which argues that any form of processing (no matter how shallow) will lay down some form of memory trace (Craik and Lockhart 1972). The specific locus of the effect however is possibly better accounted for by models which ascribe particular properties to primacy.

Having dealt in Chapter 2 with situations where differential processing across to-be-remembered items is minimised, and in Chapter 3 with the influence of extraneous material which is only processed to a shallow level, Chapter 4 turns to the conventional free recall paradigm. That is to say that arguments concerning the shortcomings of the paradigm notwithstanding, certain fundamental questions can still be posed (and require to be posed) within the true context of the 'original' recency finding. For example, is it the case that the typical 'U' shaped function obtains under conditions where the nature of the stimulus material is altered within any one list? Furthermore in the light of the considerable recent influence of the levels of processing framework, the same question can be posed making use of changes in the semantic nature of the task stimuli.

It will be argued that the provision of semantically-related material in an intentional rather than incidental learning setting affords a greater degree of objective control over processing depth, as there is abundant evidence that subjects make use of such relationships during learning. The results of the early experiments in this section will be shown to display highly dependable alterations to the normal recall profile as evidenced by the serial position functions, and that these are contingent upon changes in the material during presentation. The best account of these mini-serial position curves is provided by assuming that the pattern of processing alters as a consequence of switching from one semantic category to another, especially when the categories are presented in blocks. The major finding that each category block exhibits primacy but no recency has important bearings on several theoretical positions. Firstly it appears to dismiss the positional distinctiveness model as an adequate explanation. Secondly while it is not completely at odds with a levels approach, such an account is found to be lacking in precision so as to make detailed prediction difficult. All in all the data appear to be handled best by some of the early versions of the modal model, although this picture is not supported by the second set of experiments.

While the above experiments described findings of within-list primacy and only normal recency for terminal list items, the second set of experiments revealed evidence of recency effects across groups of related items. The size of the units involved in such a result clearly argues against a limited capacity store as being responsible and favours explanations based on a retrieval strategy. A final free recall test employed in these experiments however showed that the category-block recency effect could be removed by the imposition of a delay. In addition though there was now a suggestion of a list recency effect - a finding which it was decided should be examined in greater detail.

Chapter 5 therefore attempts to explore the nature of the list recency effect in greater depth while simultaneously examining the processing of terminal list items by continuing to employ a final free recall paradigm (after Craik 1970). List recency was found to be an enduring and highly replicable finding, and once again both the size of the units involved and the time scale of the effect argue against explanation in terms of any fixed capacity short term store and in favour of some retrieval strategy account. As regards the terminal items within any one list, examples of both positive and negative recency are encountered. These are difficult to accommodate within any existing model, but it is noted that the

findings may be the product of a somewhat unreliable effect.

The final Chapter will attempt to draw together the findings of the previous chapters in conjunction with the relevant evidence in the literature. It seems clear that none of the existing models can account adequately for all the recency phenomena observed; it appears to be the case that satisfactory explanations will depend on the paradigm adopted. To anticipate the evaluation exercise however, the evidence appears to come out in favour of a position which views recency as being multiply-determined. In addition, one important implication of the findings presented is that they indicate a departure from the traditional dichotomy of short- versus long-term. Demonstrations of recency for items, groups of items, and even lists, which appear dependent upon (a) when the testing is carried out, and (b) which cue/unit is appropriate to any retrieval strategy at that time, all emphasise 'relative' rather than 'absolute' considerations.

CHAPTER 2

THE EFFECTS OF MEMORY LOAD, PRESENTATION RATE,
AND PROCESSING STRATEGY:
EXPERIMENTS WITH A RUNNING MEMORY SPAN PARADIGM.

2 : 1 PREFACE

2 : 2 INTRODUCTION

2 : 3 EXPERIMENT 1 : THE EFFECTS OF PRESENTATION RATE
 AND MEMORY LOAD

2 : 4 EXPERIMENT 2 : THE EFFECTS OF PRESENTATION RATE
 AND PROCESSING STRATEGY

2 : 5 GENERAL DISCUSSION OF EXPERIMENTS 1 AND 2

2 : 6 GENERAL SUMMARY OF CHAPTER 2

This chapter is concerned with memory for very recently-presented information. A considerable amount of support for dual process theories of Memory derives from experiments employing the technique of free recall. In particular, a number of variables known to affect long-term memory performance appear to have their effect solely upon early portions of the recall function, while memory for terminal list items remains virtually unaltered. However, when recall is delayed for some time by some intervening activity, the superior recall of these recency items is eliminated. This set of results has led many to conclude that the recall of terminal items reflects the operation of a fixed-capacity, labile, short-term store (STS). However, it can be argued that although output strategy in this task is fairly constant, the lack of control over subjects' processing strategy during acquisition is a confounding factor. This research therefore takes this as its starting point, and begins by attempting to identify the causes of the differential processing which appears to occur in free recall. Having done so, a paradigm is sought where the crucial conditions are avoided, in order to obtain a 'purer' measure of memory for recently presented material.

2:2:1 Aspects of Processing and Retrieval

As indicated during the theoretical review in Chapter 1 a body of evidence which appeared to favour the operation of two distinct memory stores emerged during the late 1960's and early 1970's. In particular these components were identified as a vulnerable short-term store or primary memory with a small fixed capacity and a much more durable long-term store or secondary memory of possibly unlimited capacity.

The evidence for this distinction has already been considered and only a summary need be presented at this point. Briefly a number of short-term memory tasks, of which the following do not comprise an exhaustive list, produced results which lent themselves to such an interpretation : The serial probe task (Waugh and Norman 1965); the Brown -Peterson paradigm (Baddeley and Scott 1971), free recall (Glanzer 1972) and was further supported by clinical work carried out on amnesic patients with specific deficits (see Baddeley 1976).

The best illustration of these findings probably comes from the free recall paradigm where the two components are assumed to be reflected in the early and late portions of the serial position function. It will be recalled from the earlier discussion that virtually all experimental manipulations have their effect upon early parts of the recall curve (primacy plus the centre portion) while only the prevention of immediate recall tends to affect the recency portion (see Glanzer 1972 for a review of this work).

A number of objections to the interpretations placed on these data have since been lodged. As these have been discussed previously and in any case tended to post-date the beginning of the research to be reported here, they will be omitted from present consideration. Quite another approach is to critically examine the free recall paradigm; this was essentially the rationale adopted by the author. In particular, the conditions operating during input and output require careful investigation.

(i) Output Considerations: It is well established that subjects in free recall tasks tend to report the later items early during their recall (eg Murdock 1962). This strategy may not necessarily be apparent on the very first trial, but very soon develops after a small amount of experience (Dallett 1963). The same pattern of results emerges from Hamilton and Hockey (1970) although these authors interpret the effect somewhat differently. In order to ensure that all subjects perform in this way from the very first list researchers occasionally instruct their subjects to adopt such a strategy. Thus although the free recall task

theoretically permits subjects to output in any order, there is a consistent pattern of recency items being reported early during recall. The normal explanation for this finding is that subjects quickly learn that recall of terminal items is maximised by such a strategy. The pattern is of course disrupted during delayed recall, whether this is achieved by interpolating irrelevant activity after list presentation (Postman and Phillips 1965; Glanzer and Cunitz 1966) or by forcing subjects to recall earlier items first (Tulving and Arbuckle 1966). Both these situations result in impaired recency performance. It therefore seems reasonable to suppose that when left to adopt their own output strategy subjects quickly discover the Tulving and Arbuckle (1966) finding for themselves, and thereafter ensure that terminal items are recalled first.

(ii) Input Considerations: Having established that there is a fairly consistent pattern for the output of free recall lists it is necessary to examine the conditions operating during acquisition. As with most list learning experiments there is typically no control over processing strategies adopted by the subjects. This would not be particularly worrisome if it could be assumed that equal attention/processing was devoted to each list item during presentation. However there is now considerable evidence that this is clearly not the case. For example, in a series of experiments Rundus has shown that rehearsal is a function of input serial position (Rundus and Atkinson 1970; Rundus 1971). The procedure adopted was that of overt rehearsal where subjects were required to vocalise their normally covert processing. Using this technique Rundus discovered that the number of times an item is rehearsed is a decreasing function of the position it occupies in the input list. Thus early items receive a great many rehearsals while later list items receive relatively few. Furthermore, when the rehearsal protocols are examined in detail, it is observed that early items continue to be rehearsed throughout presentation of the list, including that of terminal items. It appears therefore that subjects tend to adopt the beginning of the list as an 'anchor point' for their rehearsal groupings.

The implications of these findings are potentially far-reaching. In particular, it can be argued that the portion of the curve which is assumed to reflect the short-term store (i.e. recency) is contaminated, or at the very least confounded, by the continuing process of recirculating early list material. Clearly a more desirable situation for examining and measuring memory for very recently presented information would be one where only recent and relevant items are processed and recalled.

A similar point concerning the differential processing which occurs during free recall tasks is made by Craik and Lockhart (1972) although their explanation is somewhat different from that presented above. These authors argue that the nature of the processing changes during presentation/^{and is} dependent upon a strategy switch adopted by the subject. According to their view the subject processes early items in a deeper, more semantic, fashion and then changes to a shallower, phonemic type of coding for terminal items. This latter operation is assumed to maximise the number of items held in primary memory as this mechanism's processing capacity is inversely proportional to the depth at which the processing is being conducted. Evidence drawn in support of this position includes that of Watkins and Watkins (1974) where subjects who were able to gauge the approaching end of a list exhibited recency which was superior to those who were unable to make such a judgment.

However, whether one favours an explanation based on the number of rehearsals each item receives, or one based on the type of processing devoted to each item is immaterial to the present discussion. The point being made by both these approaches (and others which could be mentioned) is that processing is not constant across all the items within the memory list. It is therefore necessary at this point to examine possible reasons for this situation.

At least two features of the task would appear to be crucial in this context: (i) That total recall of all the items presented is requested, and (ii) That each list, by definition, has a clearly identifiable beginning. If this sounds platitudinous, it can be argued that a combination of these factors has a very direct influence on the way subjects take in the memory string. Returning to the data from Rundus (1971) it will be recalled that early list items continue to appear in the rehearsal protocols, even during presentation of later list items. That is to say that the beginning of the list appears to serve as an anchor point to which later items are attached during acquisition. The implications of this for any study concerned with very recently-presented information are clear: No 'pure' (unconfounded) measure of terminal items can be achieved in a paradigm which requires total recall of fixed length lists. Under such circumstances the beginning of the list will always serve as origin of the recirculation processing which takes place and continues to take place during presentation of terminal items. It is instructive to note that in a similar vein Crowder and Morton (1969) questioned the suitability of the free recall paradigm as a vehicle for exploring pure STS phenomena. It should also be noted that such comments have received rather less attention than they deserve.

One experimental paradigm which appears to satisfy the criteria necessary for examining memory for recently-presented material is the technique of 'running memory span' (Pollack, Johnson and Knaff 1959). In this situation the subject is presented with a continuous stream of items at a given presentation rate, and the task is to report as many items as possible (or some prespecified number) from the end of the list when presentation ceases. Several important aspects of the situation should be noted. Firstly, list length typically varies from trial to trial. Secondly, the subject is never informed of the length of the list in advance of presentation. Thirdly, as noted above, total recall of all material presented is not required; only the recall of certain of the terminal items is demanded. Under such circumstances it is clear that the subject is only 'made aware' of the relevant items to be recalled when presentation ceases. At no time during input can it be assumed that the items currently being processed belong to the critical end-portion or not. Equally it can be assumed that there is no need to continue to go back and recirculate much earlier items because, after a certain number of intervening items, it is clear that they do not form part of the wanted set. As described, such an experimental task would appear to offer a purer test of short-term memory function, because at any one point in time only recent and relevant items are likely to be processed. Furthermore, it seems reasonable to suppose that a more equitable amount of attention is paid to each of the items in question. Thus the paradigm would appear to avoid the potentially confounding effects of differential processing and long-term components, while still examining recency effects.

There are examples of researchers using similar techniques in the literature. Notable amongst these are Yntema (Yntema 1967; Yntema and Meuser 1960; 1962); Kanarick and Petersen (1969) and a series of studies by Monty and his associates (eg Monty(1968); Monty and Karsh(1969); Karsh(1970)). However, while these investigations have produced results of both practical and theoretical significance, certain aspects of the tasks render them of only indirect relevance to the present discussing of running span. For example, the situation employed by Yntema in all his studies was subject-paced. No conclusions therefore can be drawn on the possible effects of presentation rate; indeed it is not clear whether all subjects took equally long to perform the task. Other investigations cited employed experimenter-paced tasks and all of these showed effects of presentation rate with faster rates producing poorer recall performance (e.g. Kanarick and Petersen 1969; Karsh 1970).

Similarly effects of memory load were found when this variable was manipulated (e.g. Kanarick and Petersen 1969).

All these studies, including those of Yntema however, can be described as variants of a multi-source-monitoring situation. That is to say that they all require subjects to attend to a variety of information sources (up to 10 in the Kanarick and Petersen 1969 experiment) on which material may be presented for some limited period of time. On any one trial a source is either 'updated' to present new information which supercedes all previous information on that channel, or it is 'interrogated' to establish whether the subject is aware of its current status (i.e. the most recent information to have been presented via that source). Because of this use of a large number of information channels, the experiments clearly introduce possible complications of attention allocation and consequently differential processing of items. Indeed Kanarick and Petersen (1969) demonstrated that such selectivity can be employed effectively to help overcome the overload problems, provided that certain sources are designated as having high priority, or high value in terms of a costs/payoff matrix. Even in a simpler variant of the task with relatively few sources, subjects appear to process and rehearse the material spatially, beginning with the left-hand source, in much the same way as is the case with fixed length lists (Monty 1968; Monty, Taub and Laughery 1965).

Thus there are grounds for assuming that the above findings derive from more complicated versions of the basic running memory span task. The results therefore might be a product of these extra factors introduced into the situation - particularly those associated with a large number of information sources and the related spatial component which this introduces into the task. These qualifications notwithstanding, if the tasks reported convey any of the essence of the running span paradigm, then they provide very strong suggestive evidence that the task is significantly affected by (i) Memory load, (ii) Presentation rate and probably (iii) Processing Strategy.

At this juncture it should be noted that none of these factors has any place in STS function as typically measured by the recency effect in free recall. It will be recalled that memory load - as measured by the length of the list - has no effect upon recall of the terminal items. For example, if the data of Murdock (1962) are 'right-justified', it can be seen that the recency component of lists differing by as many as 20 items is virtually identical and the effect of additional load is carried by the pre-recency portion. This result has been amply replicated, notably by Postman and Phillips (1965). Essentially the same pattern of results applies to variations in the rate of presentation where the data of

Murdock (1962) can again be cited, along with that of Glanzer and Cunitz (1966). The effect of manipulating these and other variables mentioned in the introductory chapter therefore all points towards the invariance of recency. From this evidence it can be assumed that the final factor mentioned above - that of processing strategy - is only important in the recency context in that it too remains constant. That is to say that while the strategy may be different from that applied to earlier list items it remains relatively invariant within the processing of the terminal items. This is essentially the view advanced by the levels of processing framework of Craik and Lockhart (1972). Consequently if the arguments advanced here in support of running memory span offering a 'purer' measure of short-term memory function are valid, and if running span performance proves susceptible to the variables noted, then theories which equate recency with STS are inevitably called into question.

In order to examine this possibility a series of experiments employing the running memory span procedure was conducted. To avoid any possible confounding effects present in the multi-source updating tasks mentioned above single streams of homogeneous items served as stimuli. To anticipate the experiments which follow three main variables were selected for manipulation within the basic paradigm viz. memory load, rate of presentation and processing strategy.

2 : 3 EXPERIMENT 1 : THE EFFECTS OF PRESENTATION RATE AND
MEMORY LOAD

2:3:1 Method

Apparatus:

The basic system used to present stimuli to the subjects comprised a Teletype machine, a closed circuit television camera and two monitors. Paper tape containing the stimulus material was run on the Teletype such that the memory lists were output in a vertical manner, one item at a time, at the left-hand side of the printout. A mask with one circular hole was fixed to the top of the Teletype to ensure that only one stimulus item was visible at any one time (rather like the window of a conventional memory drum). The camera was mounted on a tripod in such a way that only the mask and the hole through which the stimuli passed were in the field of view. Use of a zoom lens permitted magnification of the stimuli and the resulting image of the window presented on the monitors was approximately 5 centimeters in diameter. (At no time during any of the experiments to be described did any subject report difficulty reading the stimuli). To avoid any possible distracting effects of noise from the Teletype when in operation, subjects and the monitors being viewed were located two rooms away in the same corridor.

Stimuli:

The stimulus material consisted of letters of the alphabet with the exception of vowels (in order to minimise the occurrence of words in the memory lists). List lengths of 12 to 28 items inclusive were selected making a total of 17 different lengths in all. A computer programme generated the lists and produced the output on paper tape ready to be fed into the Teletype. The programme randomly sampled the list lengths on a 'without replacement' basis and the letters within each list on a 'with replacement' basis. In addition each list was preceded by a countdown sequence of the three digits 3, 2, 1 while the end of each list was signalled by a series of six asterisks which also acted as the recall cue.

To ensure that the lists were output in a serial, vertical fashion at the left-hand margin of the Teletype printout 'return' and 'line feed' operations were inserted between each stimulus item. Variations in the rate of presentation were achieved by making use of the fact that the Teletype functioned at 10 characters (or operations) per second. A minimum of three operations - print character, 'return' and 'line feed' - is required to present one letter and return to the same position to print the next item. Thus the fastest presentation rate possible using

this method was 3.3 items per second. Slower presentation rates were attained by inserting additional 'return' and 'line feed' instructions as spacer items between each letter. The same method was employed to include a 15 second gap between each list during which recall could be recorded.

In this way 6 blocks were constructed such that each block contained all 17 list lengths. These 6 basic blocks were reproduced 4 times with different numbers of spacer items in order to achieve the 4 presentation rates described in the experimental design below.

Design:

Four presentation rates and 3 memory load conditions were tested in the experiment. The rates were 3.3, 1.67, 1.1 and 0.8 items per second, while the memory loads were the last 4, 6 and 8 items respectively. A mixed design was employed with presentation rate being tested as a between-subjects variable, and memory load as a within-subjects variable. Within the 6 blocks of lists presented to each group of subjects, memory load was varied in an ABCCBA design where A=4 items, B=6 items and C=8 items.

Instructions and Procedure:

The nature of the task was explained in full to the subjects during which sample sequences were shown at the rate appropriate to their allotted condition. Extensive pilot study studies had shown that rehearsal strategies varied considerably across subjects on this task. An attempt was made therefore to minimise this source of variance by asking subjects not to attempt elaborate encodings, and merely to concentrate particularly on the item most recently presented. This procedure is similar to that employed by Waugh and Norman (1965) in their serial probe study. Subjects were told that as soon as the first asterisk appeared signalling the end of the list they were to commence writing their recall of the terminal items on the response sheets provided. These sheets were constructed with arrays of boxes appropriate to the recall load being demanded on that trial. The extreme right hand box always represented the last item presented in the list (and indeed was labelled as such), the second from the right represented the penultimate item, and so on. Although subjects were permitted to output their recall in any order they wished, they were told to convey the order of presentation wherever possible by placing each item in its corresponding box.

A practice session was administered prior to the main experiment in order to familiarise subjects with the demands of the task. Fifteen lists were presented to them, five under each of the memory load instructions.

During the main session subjects were given a two minute rest after each block of 17 lists, at which time they were also reminded of the recall load for the subsequent block.

At the end of the experiment all subjects were given a questionnaire. In this they were asked to comment on the difficulty of the task and how well they thought they had performed according to the instructions.

Subjects:

Forty student volunteers from the University of Stirling served as subjects in the experiment. They were tested in groups of 10 with each group randomly assigned to one of the four presentation rates.

2:3:2 Results and Discussion

The raw data from all conditions were analysed according to two scoring methods. For the first of these - the 'strict order criterion' - items recalled had to be located in boxes which corresponded to their appropriate place in the input sequence before a 'correct' could be awarded. Under the second method - the 'lenient criterion' - credit was given for every item recalled which belonged to the critical set, without regard to order. The results of these analyses can be seen in Figure 2:1 expressed as the average number recalled per list.

From this several features of the results are apparent. Firstly, as might be expected, recall is superior when scored according to the lenient criterion than the strict order criterion, and this seems to be the case for all memory load conditions and all presentation rates. Secondly, increasing the presentation rate results in poorer recall performance, and this holds true for both scoring methods employed. Thirdly, it appears that, in general, recall is higher the greater the memory load condition. One qualification should be attached to this last conclusion : Namely that performance under all loads tends to converge with increasing rate when recall is measured by the strict order criterion (Figure 2:1, panel (b)). Comparison of this with Figure 2:1, panel (a) suggests that this limit is set by the demand to preserve the order of the information presented.

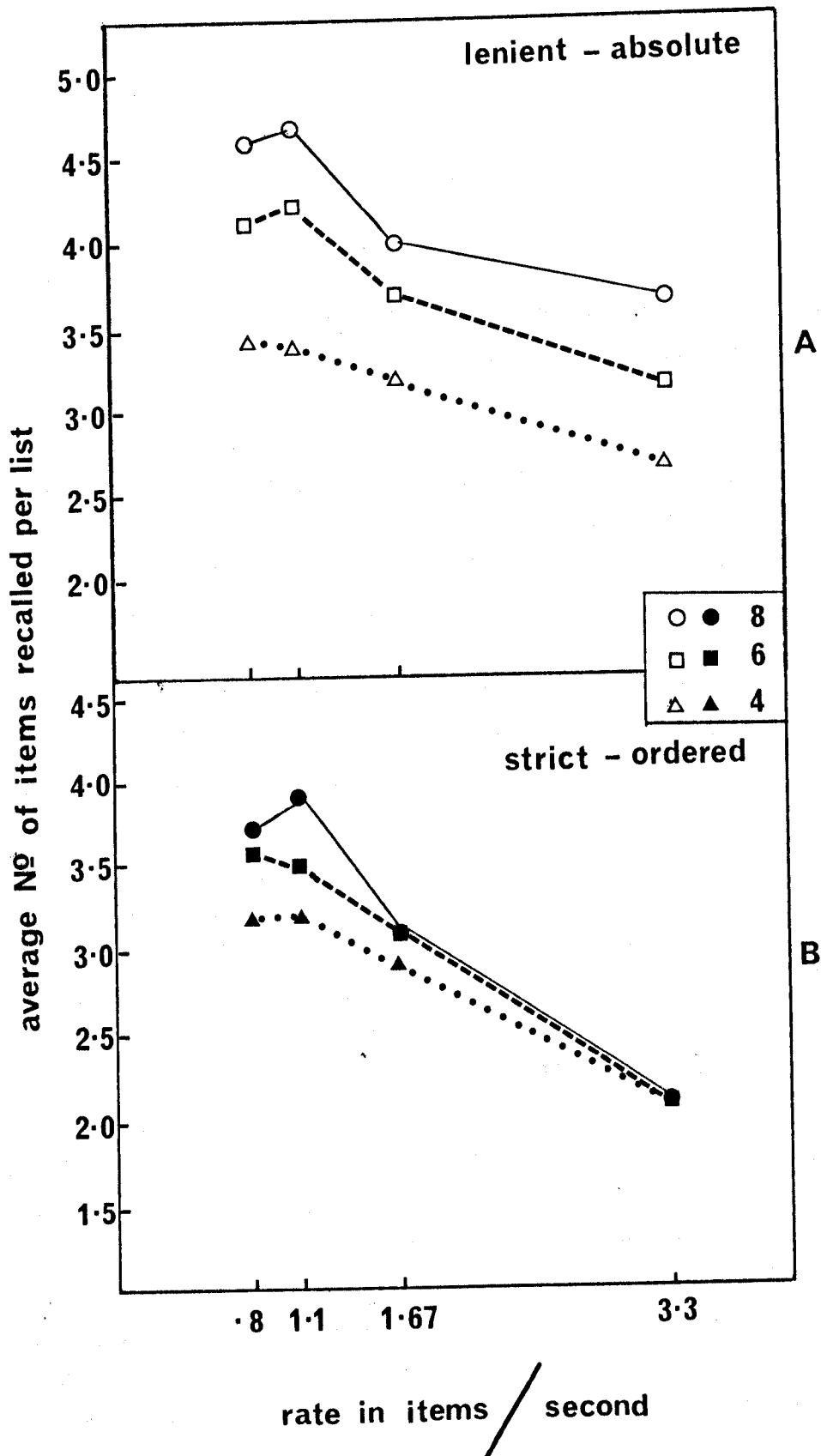


Figure 2:1 Average number of items correctly recalled per list as a function of rate for each memory load condition. Panel A - lenient scoring; Panel B - strict order scoring method.

Prior to submitting the results to statistical analyses one final breakdown of the data was conducted. As the experiment incorporated the memory load factor in the design as an ABCCBA format, a subdivision into first and second halves of the test is possible. When this was accomplished performance on the second half was noted to be superior to that obtained for the first half. In order to check whether this difference was statistically significant, this factor was included in the analysis of variance summarised below.

A four factor analysis of variance was carried out on the data from each subject. Presentation Rate was treated as a between-subjects factor, while memory load, test half, and scoring criterion were treated as within-subject factors. This revealed that all main effects were highly significant. (Presentation rate ($F(3,36) = 15.86, p < .001$); memory load ($F(2,72) = 87.45, p < .001$); test half ($F(1,36) = 19.75, p < .001$); and scoring criterion ($F(1,36) = 318.49, p < .001$)). Turning to the interactions, the rate x memory load term was significant ($F(6,72) = 4.11, p < .01$). This confirms observations made from Figure 2:1 that the improvements gained at slower presentation rates are more evident for conditions with a larger memory load. Furthermore this is particularly apparent in the results scored by the strict order criterion (Figure 2:1 panel (b)) and indeed this is borne out by the significant three way interaction rate x memory load x scoring criterion ($F(6,72) = 3.20, p < .01$). Presumably the slower presentation rate enables more efficient acquisition and this is likely to be of most benefit to conditions where recall of a large number of items is requested and the retention of order information is important. This is compatible with two other significant interaction terms of rate x scoring criterion ($F(3,36) = 11.68, p < .001$), and memory load x scoring criterion ($F(2,72) = 132.37, p < .001$).

Although the main effect of test half was significant as noted above (indicating a small but reliable improvement during the second part of the session) only one of the interaction terms including this factor was significant. This was the test half x scoring criterion term ($F(1,36) = 10.83, p < .01$) and indicated that the improvements during the experiment were slightly greater under the strict order scoring method. Naturally performance as measured by this method was lower to start with, and therefore there was more room for improvement. Gains with both scoring methods during the second half were however fairly small. None of the other interaction terms approached significance, including the four way interaction rate x memory load x test half x scoring criterion ($F(6,72) = 1.42, p > .05$).

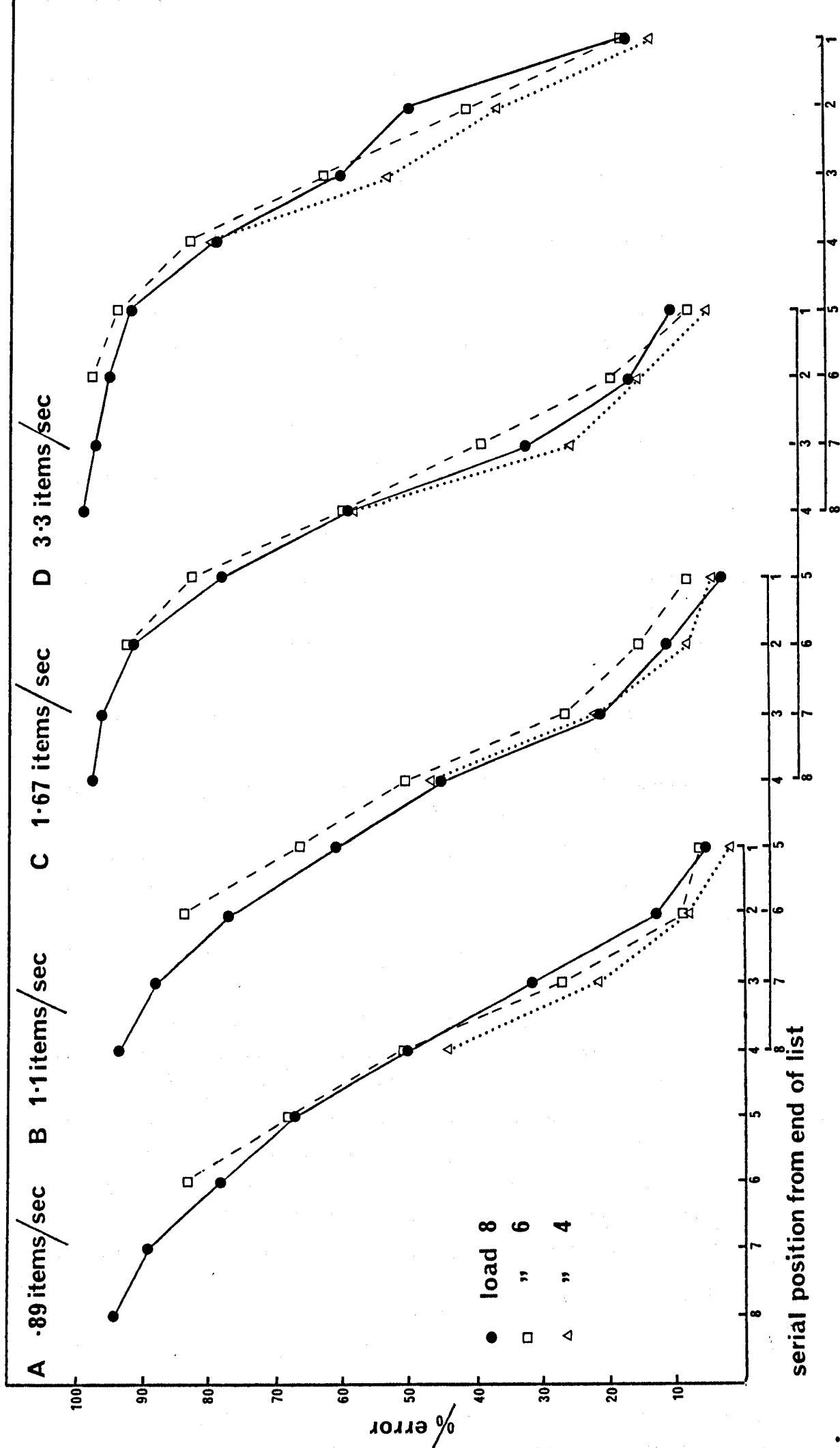


Figure 2:2 Percentage error scores by serial position for each memory load condition, and as a function of presentation rate.

Several features of these results merit further comment. In the first place it should be observed that the running memory span task is clearly a very demanding one. Evidently the uncertainty concerning the critical set of wanted items, and the continuous nature of the processing thus forced upon the subject, results in performance levels considerably lower than one would expect on the basis of more conventional studies of fixed-length lists. This is demonstrated most convincingly by the memory load 4 condition. Despite the fact that only four items have to be recalled - a figure which is well within the limits typically quoted for traditional memory span (Miller 1956) - performance falls far short of perfect. Moreover, Figure 2:1 indicates that this situation still obtains even when order information is disregarded in marking the recall. This finding however is not unique to the literature. For example, in the studies conducted by Yntema cited earlier (Yntema 1967; Yntema and Meuser 1960; 1962) a similar pattern of results emerged. Indeed Yntema was forced to conclude that it may be difficult for subjects to keep track reliably of more than two sources which were being continuously updated (Yntema 1967). Certainly the ability to keep track of information which is constantly changing in an unpredictable fashion is extremely low. The value of the present results however rests in the fact that this finding has now been replicated in a situation where only one source of information is involved and has to be monitored. Unconfounded by the attentional factors inherent in multi-source monitoring tasks, the present results are therefore potentially far reaching and appear to indicate a very basic limitation on performance.

The results of Experiment 1 were also subjected to serial position analysis, and the outcome of this is depicted in Figure 2:2. (Only those data scored according to the strict order criterion have been included here). From this it can be seen that performance is best for the very last list item, and thereafter deteriorates as a function of the number of intervening items. That the function never attains asymptote is evidenced by the curves for the 'memory load 8' condition where it can be seen that performance on the items furthest from the end of the list drops virtually to zero. The monotonicity of this decline is most evident in the fast presentation rate condition (Figure 2:2, panel (d)), although it must be admitted that misperceptions may also have occurred in this condition.

In qualitative terms at least therefore the function bears a remarkable resemblance to the typical free recall recency effect before the latter intersects with the stable asymptotic region (cf for example Murdock 1962). It is perhaps even more comparable to the curve obtained by Waugh and Norman (1965) in their original serial probe study in that

these authors also report a function which gradually approaches zero recall the further the item is from the end of the list. This is perhaps hardly surprising; both the Waugh and Norman (1965) experiment and the present study have a number of features in common. Firstly, they are both concerned with memory for very recently-presented material. Secondly, both studies employed an instruction designed to minimise elaborate rehearsal strategies. And finally, both the serial probe task (which requires the recall of the item which followed the probe) and the present results as depicted in Figure 2:2, involve a knowledge of order information as well as item information.

Quite apart from the similarities in the appearance of the functions noted above, there are also grounds for assuming that the data obtained in Experiment 1 are also quantitatively similar to the more traditional forms of recency obtained with predictable fixed-length lists. For example, the range of scores obtained with the running span paradigm as depicted by the mean number correctly recalled per list (Figure 2:1) is not far removed from certain capacity estimates of primary memory which assume the mechanism capable of holding between 2 and 4 items (e.g. Baddeley 1970; Murdock 1972). Thus on the face of it therefore, there appears to be strong suggestive evidence that the results of Experiment 1 can be attributed to the operation of the same mechanism as is frequently deemed responsible for normal recency effects - primary memory or the short-term store. Thus in this view the apparently fundamental limit upon performance mentioned several paragraphs ago, which seems to be tapped by the running span task, would appear to be simply explicable in terms of the limited capacity of the short-term store. Such a view is appealing given the similarities between the results so far discussed and because it encompasses yet another experimental paradigm within a single explanation. There are however a number of features of the results of Experiment 1 which suggest that this would be at least an oversimplification of the situation, if not totally misleading. Consideration will now be devoted to these aspects.

Firstly, if the results of Experiment 1 are to be explained as being the product of a limited capacity mechanism, capable of holding up to 4 items then it is unclear why, even in the memory load 4 condition, performance is always less than perfect. After all the system has no requirement to engage in reprocessing any items other than the current ones, and consequently the critical set should be in a state of current storage ready for access when presentation of the list ceases. This criticism is perhaps a trifle harsh since it could be argued that 4 items is usually beyond the mechanism's capabilities (unless some recoding into

'chunks' has been achieved) and therefore figures of around 3 items are much more common (cf Watkins 1974).

Perhaps more serious is that the quantitative similarities between PM capacity and the results of Experiment 1 are strongest when the scoring of the latter includes consideration of the order of the items (Figure 2:1 panel (b)). Examination of the lenient criterion results (Figure 2:1 panel (a)) indicates that several conditions exhibit scores in excess of 4 items. As noted earlier, with the possible exception of the Waugh and Norman (1965) task which contains an inherent amount of order information, the majority of other estimating procedures are based on free recall. Thus most of the evidence points to the conclusion that output from primary memory should still be held down to around 3 items, even when order information is not taken into account. Furthermore, the present results cannot readily be dismissed by assuming that the additional recall is the product of the secondary memory system or longer-term storage. Scrutiny of the functions depicted in Figure 2:2 reveals that the curves do not level off at any stable asymptote but rather they drop to around zero scores - a situation resembling the original Waugh and Norman (1965) data.

Finally in this set of comments criticising the equivalence of running span with primary memory or the short-term store is the very damaging result that the former is affected significantly by variations in the presentation rate. This is evident from the graphs in Figure 2:1 and is substantiated by the results of the analysis of variance reported previously. As was pointed out in this chapter and in Chapter 1, there are now innumerable studies which document the invariance of free recall recency (and therefore the short-term store) in the face of changes in the rate of the presented items. Thus the limiting factor for most of the dichotomous positions is the capacity of the store held responsible for the recency effect; presentation rate can have no effect upon this immutable figure. The finding in the present results that not only does decreasing the rate significantly improve recall beyond the estimates of PM capacity, but looks likely to go on doing so if still slower rates were included, is suggestive of a totally different kind of limitation. Indeed the present results argue more for a limitation upon processing than one of capacity. The running span task therefore has so far proved susceptible to both variations in the imposed memory load, and the rate of presentation. As such the results would appear to have ^{more in} common with models which implicate a limited processor (eg Broadbent 1958) rather than a store possessing a fixed number of slots such as the Waugh and Norman (1965) model and its derivatives (eg Glanzer 1972).

The running span task therefore has so far proved susceptible to manipulations of memory load and rate of presentation. These findings are in direct conflict with most of the documented evidence on recency effects. In the light of the rationale presented earlier in this chapter which argued that running span was possibly a purer measure of memory for recently-presented material, clearly some radical reappraisal of the dichotomous position is necessary. However further consideration of this state of affairs will be postponed until Experiment 2 has been reported. In the meantime attention will be turned to one final piece of evidence which emerged from Experiment 1, and which in fact furnished one of the principal reasons for conducting the next experiment in the series.

Thus far no mention has been made of the post-experimental debriefing which was carried out immediately after the testing session. During this subjects' reactions to the task and its difficulty were elicited, and they were asked to write down their subjective comments on a sheet provided for the purpose. The format of this exercise was fairly loose, but certain general insights would appear to be forthcoming. These can be grouped under two main headings: (i) Comments on the difficulty of the task per se, and (ii) Comments on the difficulty of complying with the instructions to take in only one item at a time. Taking the first of these categories, it is abundantly clear that the majority of the subjects found the task a difficult one, as was expected on the basis of similar experiments in the literature. Moreover this difficulty was most evident in the high memory load conditions i.e. the '6' and '8' conditions. However, turning to the question of whether the experimental instructions were adhered to, a somewhat different kind of consistency emerges. In this connection, the fact that each group performed the task at a different presentation rate is particularly instructive. The first observation which can be made is that all groups experienced some difficulty in obeying the instruction to take in only one item at a time. For the fast group (3.3 items per second) however this appeared to be because the rate of presentation exceeded the rate at which subjects could verbalise the items comfortably. On the other hand for all the slower groups the difficulty seemed to lie in effectively suppressing a tendency to group the items during input. Thus in the 3.3 items/ second group only two subjects reported any form of grouping strategy, while five subjects claimed that they could not process each item, and felt that a number of items were consistently missed during acquisition. In the 1.67 items/ second group, 2 subjects claimed that they grouped items for part of the task and 2 reported that they did so for most of the task. In the 1.1

items/second group 2 subjects admitted grouping some of the time, while 6 subjects now claimed similar elaborate strategies for most of the task. And finally, in the .8 item/second group, again 2 subjects felt that they rehearsed in groups for certain periods during the experiment while a total of 8 admitted that they did so for most of the time. Thus the picture which emerges is a growing tendency to rehearse in groups as presentation rate decreases. Whether this actually represents some automatic activity over which the subject has little or no conscious control (eg in the case of a certain number of items which are always 'available' and cannot be excluded from conscious thought), or whether it is merely a strong temptation which is difficult to resist under the possibly boring constraint of a slow presentation rate, is impossible to assess on the evidence available. What is clear however is that despite a mild instruction to the contrary, grouping rehearsal strategies were employed to some extent, and this was especially the case for the larger memory load conditions and slower rates of presentation. In this respect the results confirm the findings of the earlier pilot work conducted with this paradigm. On the basis of this it was decided to explore this aspect of the task more fully in a study specifically designed to examine the effects of different modes of processing activity.

2 : 4 EXPERIMENT 2 : THE EFFECTS OF PRESENTATION RATE AND PROCESSING STRATEGY

2:4:1 Introduction

Experiment 1 has already demonstrated significant effects of memory load and presentation rate upon performance in the running span task. However that study also appeared to offer tentative evidence that processing strategy plays some part. It is always necessary to be cautious in placing much weight on conclusions which are unpredicted, and therefore post hoc. Moreover this should be even more true of situations where the conclusions depend heavily upon subjects' introspective remarks. Nevertheless the post-experimental debriefs ought not to be ignored as they provide strong suggestive evidence that strategy during acquisition does play a role in running span, and further that it appears to interact with presentation rate. Furthermore, this finding emerged despite a mild instruction designed to remove the possible confounding effects of different encoding patterns the subjects might have employed. On the basis of the potential importance of this finding, it was decided to examine this factor more directly. The rationale was straightforward: If different processing strategies could be held more or less constant across a variety of presentation rates, then both the effects of rate and strategy could be examined relatively independent of each other.

2:4:1:2 Early Experiments On The Effects Of Presentation Rate

It could be argued that many of the earlier experiments in the literature, by ignoring the possible effects of strategy, suffered from just such a confounding mentioned above. Prior to the mid 1960's most of the short-term memory experiments which manipulated presentation rate were concerned with resolving the controversy over whether decay (Brown 1958) or interference (Postman 1961) was predominantly responsible for forgetting. That is to say that the question being posed was whether items spontaneously faded with the sheer passage of time, or whether their loss was due to the presence and nature of other items processed. The results of much of this early work however were equivocal. For example studies which appear to demonstrate beneficial effects of fast presentation rates would include those of Conrad and Hille (1958) and Fraser (1958). Such results would tend to support a decay theory position as under conditions of fast presentation items do not have to be held for so long, and therefore the traces are less likely to have faded. In contrast, superior performance using slow presentation rates emerges from studies

by Mackworth (1962) and Yntema, Wozencraft and Klem (1964). Significantly for the present discussion a similarly confusing picture is evident from the few studies which have employed the running memory span technique. Thus Crowder and Morton (1969) found no effect of presentation rate, while Pollack, Johnson and Knaff (1959) demonstrated superior performance with slower rates of presentation. Typically the one variable neglected in all these experiments has been processing strategy. This is perhaps hardly surprising; the entire area of rehearsal and encoding operations had long been neglected owing to the difficulties of studying such a covert process. Nevertheless, the subject of processing strategy may well be crucial in such circumstances as evidently different input rates afford greater or lesser opportunities for rehearsal. Furthermore, optimum performance at one rate may require one form of processing, while optimum performance at another rate may require a totally different acquisition strategy. Thus the very real possibility exists that acquisition strategies may have varied across the above experiments cited, and may even have altered within any one experiment as the conditions changed. Under such circumstances any rate effect would be confounded. An experiment directly concerned with determining the effects of processing strategies under different input rates could thus have wide implications in resolving some of the confusions in the literature. More specific to the present investigation it would more readily settle the issue of whether recall of very recently-presented material is affected by this factor.

The method adopted (and which will be described in detail shortly) involved instructing and practising the subjects to adopt one of two acquisition strategies. The first of these - a relatively passive mode - was similar to that employed in Experiment 1. The main difference was the emphasis placed upon obedience of the instructions. Whereas in Experiment 1 subjects were merely 'advised' to process items singly, this time they were instructed more firmly, and this was emphasised repeatedly throughout the task. The second strategy - a relatively active mode - demanded that the incoming material was to be rehearsed in groups of three items. Once again this instruction was repeated throughout the testing session. It was felt that these two modes of operation represent attempts to indicate extremes upon a continuum which defines various ways of organising the input stream. In addition, although the passive condition involves little, if any, organisation, it does not lay itself open to the criticisms which can be levelled at the more superficial orienting tasks used in some incidental learning paradigms viz. that the nature of the processing (e.g. cancellation of certain letters) is hardly appropriate to the subsequent demand for recall of whole words. In the condition

to be employed in the present experiment the stimuli (letters) require to be processed as letters, and the only difference is that they are not to be elaborately linked with other material in the sequence. As regards the group rehearsal condition, although the details of the process involved are not completely understood at present, a number of studies point to the beneficial effect of such grouping when conditions are appropriate.

2:4:1:3 Effects of Grouping in Fixed-Length Lists

There are a number of ways in which material to be memorised can be organised into groups. These include spatial, temporal and rhythmic methods, and they can be imposed upon the material by the Experimenter, or subjects can be induced to adopt the required mode by instruction. In the context of fixed-length lists where these various methods have been examined, the results permit the general conclusion that grouping results in superior recall performance (e.g. Conrad and Hille 1957; Wickelgren 1964). One of the most effective methods is clearly that of temporally grouping the items during presentation by inserting pauses every so many items in the input sequence. For example, Ryan (1969) found this procedure to be superior to a variety of other conditions which included inserting 'pips' during presentation; instructing subjects to group in the absence of such cues; or a combination of both. (All conditions however were superior to an ungrouped control list). Moreover the superior performance in the temporal condition was not due merely to increased time per se as overall presentation time for all list conditions was equated. In a further experiment Ryan (1969, Experiment 2) went on to show that the advantage of temporally grouped material is most clearly demonstrated when the pattern of grouping is regular rather than irregular. Indeed these studies highlight yet another feature to emerge from examination of grouping viz. the size of the groups being processed.

Evidence from a number of studies on group size reviewed by Ryan (1969) suggests that grouping in 3's (and to a lesser extent 4's) frequently yields optimum recall performance. Once again this result tends to come from studies where the pattern was imposed upon the material, or where subjects were instructed to impose the pattern during their acquisition of the list. However it is interesting to note that additional support for this finding can be found in self-paced learning tasks where the subject is free to choose his own group size. Thus, using measures of pausing as an indication of encoding behaviour (and therefore processing strategy) Wilkes, Lloyd and Simpson (1972) noted that three was the most commonly preferred group size. Also, returning to the post-experimental debriefs

used in Experiment 1 of this series, of those subjects who specified the size of the group they used, the majority claimed to be rehearsing in groups of three. The generality of this finding therefore is clearly significant, and probably has important implications for the mechanism of rehearsal. However for the purposes of the experiment to be described, it is sufficient to note that grouping in 3's is both the preferred mode, and apparently the most efficient.

2:4:2 Method

The apparatus and basic method were similar to that described for Experiment 1. The main differences in the present experiment can be summarised as follows: (i) The nature of the instructions and the practice sessions administered to encourage the processing strategies required; (ii) Only 2 groups of subjects were employed, with each performing according to one of the two acquisition modes; (iii) As a result of this presentation rate now becomes a within-subjects factor; (iv) Only one memory load - the 8 item condition - was employed throughout the task; and finally (v) A new slow rate of .56 items per second was substituted for the previous .8 items per second in order to give a broader distribution of rates.

Stimuli and Design

For convenience the same pool of tapes containing the stimulus material which had been prepared for Experiment 1 was used in the present experiment. This time however 8 blocks of 17 lists (representing all list lengths from 12 to 28 items inclusive) were selected. As before list length varied randomly from trial to trial. Each list was again preceded by a countdown sequence and followed by a series of asterisks which signalled recall.

The four presentation rates adopted were .56, 1.1, 1.67 and 3.3 items per second. Within the 8 blocks of lists these rates were employed according to an ABCDDCBA design, beginning and ending with the slowest rate. The same set of lists thus constructed served as material for both groups of subjects.

Instructions and Procedure

The nature of the task was explained fully to the subjects during the briefing session during which sample sequences were shown. Subjects allocated to the relatively passive strategy - the 'single item' group - were told that at all times they were to concentrate hard and only upon

the item currently being displayed. They were told that this would be likely to be difficult, both when items were being presented very quickly where there was an obvious danger of missing particular events, and when the items were being presented slowly when there would be a strong temptation to group items. It was emphasised however that they were to persevere with the strategy they had been given, whether or not it felt unnatural under certain conditions, as it was vital to the success of the experiment that they did so. Subjects awarded the active strategy - the grouping condition - were instructed to rehearse the stimuli in groups of three items. As with the passive group they were told that this strategy was to be obeyed at all times, even when increases in presentation rate made it difficult to accomplish. Both groups were then given a total of 10 practice lists, 5 at the fastest rate and 5 at the slowest rate, in order to familiarise them with the task and how they had to perform it.

During the main testing session the experimenter issued reminders and encouragement prior to beginning each new rate block. The 'single item' group were told continually to shut out all thoughts of items other than the immediate one which could be repeated as often as the time allowed, while the 'grouping' condition subjects were exhorted to 'roll' up the items into groups of three, then to leave that group and begin the process anew.

As in Experiment 1 response sheets were provided and subjects were asked to use these to write their recall, conveying the order of the material where they knew it, and at least getting the items down somewhere when they did not.

Following the main experiment all subjects were asked to comment on the difficulty of the task and their ability to comply with the strategy allocated to them.

Subjects

Twenty student volunteers from the University of Stirling served as subjects in the experiment. None had taken part previously in Experiment 1. Ten were assigned at random to the single item strategy and ten to the grouping strategy. Subjects were tested in groups according to their allotted condition.

As in Experiment 1, the raw data were scored according to both a strict order criterion, and a lenient criterion where order information was disregarded. The results of this analysis for both groups of subjects and all presentation rates can be seen in Table 2:1. The data are expressed as the average number of items correctly recalled per list, and are further subdivided into first and second halves of the test. From this table clear effects of presentation rate can be detected, and in line with Experiment 1, slower rates provide the best recall performance. Contrary to Experiment 1 however the effects of test half no longer appear to be consistent. (It will be recalled that memory load was the replicated variable in Experiment 1, whereas it is the rate factor which is repeated in both halves of this experiment). As the effects of processing strategy are somewhat obscured in the table, Figure 2:3 depicts the same data with performance now pooled over the first and second halves of the test. From this graph it appears that when recall is measured by the lenient criterion, recall is better with the single item strategy at the fastest rate, but the reverse is the case for slower rates of presentation. Under strict order marking however, performance under both processing modes is approximately equal at the fastest rate, and thereafter improves with decreases in rate although the benefits seem more marked in the grouping strategy subjects.

A four factor analysis of variance (2 processing strategies x 4 rates x 2 test halves x 2 scoring methods) was carried out on the raw data above, with processing strategy treated as a between-subjects comparison. This revealed that the main effect of processing mode was not significant ($F(1,18) = 2.20, p > .05$), nor was that of test half, confirming the observations from Table 2:1 ($F(1,18) < 1$). However the remaining effects of rate and scoring criterion were highly significant ($F(3,54) = 86.44, p < .001$) and ($F(1,18) = 181.84, p < .001$) respectively. While the overall effect of processing strategy was not significant as noted above, the contribution of this factor is illustrated in the interaction terms. Thus the strategy x presentation rate term was significant ($F(3,54) = 6.2, p < .01$). Reference to Figure 2:3 shows that this takes the form of proportionally greater benefits accruing to the grouping strategy subjects as rate decreases. Similarly the strategy x scoring method term was highly significant ($F(1,18) = 23.03, p < .001$). Examination of both Table 2:1 and Figure 2:3 explains this by revealing that while there was little difference between the two strategies as measured by the lenient criterion, there was a considerable difference in

Rate		.56	1.1	1.67	3.3
Test Half	1st	1st	1st	1st	1st
	2nd	2nd	2nd	2nd	2nd
GROUPING STRATEGY	Lenient	4.7 4.4	4.2 4.1	3.7 3.7	2.6 2.7
	Strict	4.0 3.8	3.6 3.8	3.2 3.3	1.6 1.7
SINGLE ITEM	Lenient	4.2 4.2	4.2 3.9	3.6 3.7	3.1 3.1
	Strict	2.7 2.9	2.9 2.8	2.3 2.4	1.6 1.5

Table 2:1 Average number of items correctly recalled per list for both strategy conditions under all presentation rates, subdivided according to test half.

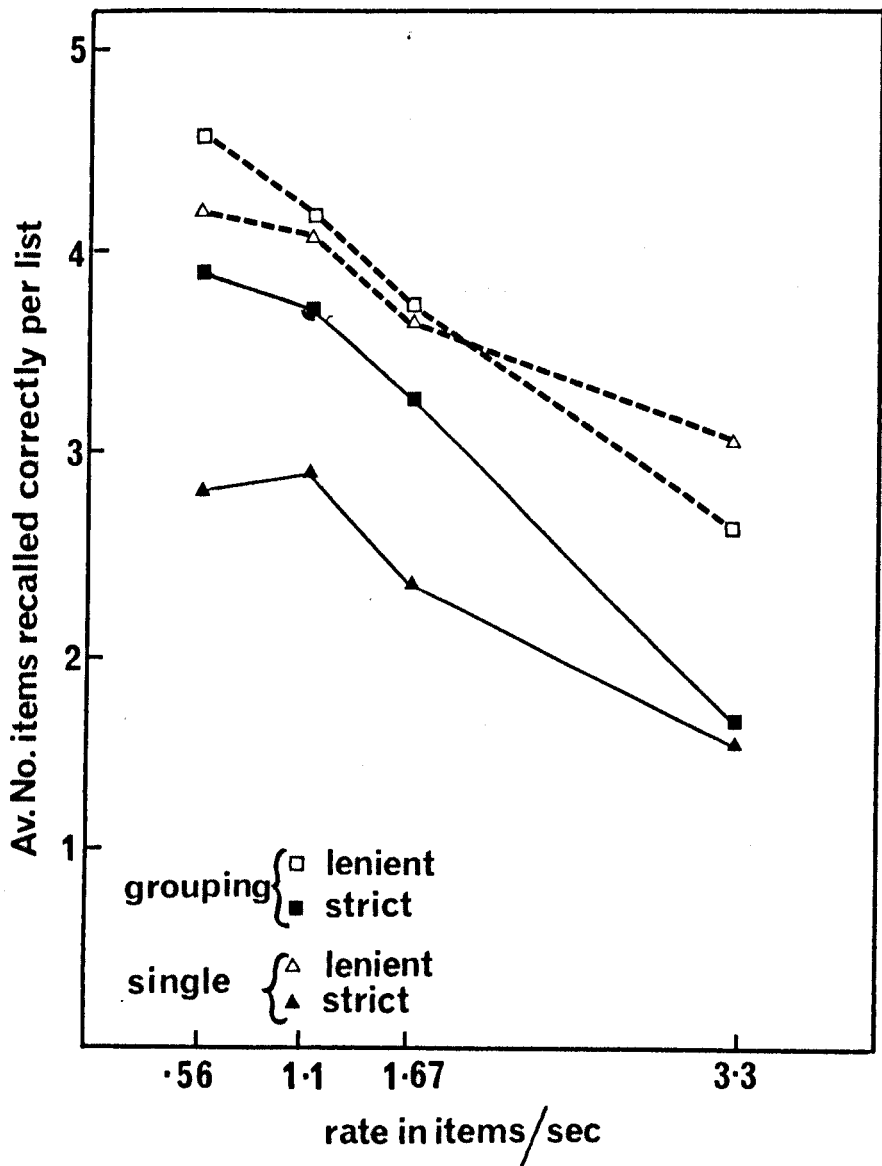


Figure 2:3 Average number of items correctly recalled per list for both strategy conditions as a function of presentation rate

favour of the grouping strategy when order information was taken into account. This conclusion is further supported and amplified by the significant rate x scoring method interaction ($F(3,59) = 7.37, p < .001$). Scrutiny of Table 2:1 reveals a small overall tendency for absolute scores (performance as measured by the lenient method) to drop from the first to the second half of the test, while if anything, the ordered scores tend to go in the opposite direction. These differences although fairly small were found to be significant as evidenced by the test half x scoring method interaction ($F(1,18) = 5.35, p < .05$). This result however is further complicated by the significant three way interaction of rate x test half x scoring criterion which shows that speed of presentation can also affect the direction of these differences ($F(3,54) = 2.94, p < .05$).

Clearly one of the most important findings to have emerged from the data thus far is the particular influence of the grouping strategy in benefitting the ordered recall scores. This finding is in complete agreement with previous results on the effects of this variable (eg Ryan 1969). In order to examine this effect in greater detail, the data were further broken down by input serial position. The results of this exercise can be seen in Figure 2:4. Performance, expressed as percentage error for each position within the list, is shown for all 4 rates and both processing strategies. From these graphs it is immediately apparent that processing groups of three items is vastly superior to taking in items singly at all but the fastest rate. Furthermore the functions for the single item subjects are characterised by a fairly steep and apparently monotonic decline in performance as one proceeds backwards from the end of the list, while the grouping functions tend to take on a reversed 'S' shape, especially at the slower rates.

Although these results would appear to be fairly clear cut, a four factor analysis of variance (2 strategies x 4 rates x 2 test halves x 8 serial positions) was conducted on the raw data to confirm the observations made on the basis of Figure 2:4. Processing strategy was again treated as a between-subjects comparison, while the other factors were within-subjects. This revealed significant main effects of strategy ($F(1,18) = 7.03, p < .05$); presentation rate ($F(3,54) = 83.91, p < .001$); and serial position ($F(7,126) = 267.9, p < .001$); but not for half of test ($F(1,18) < 1$). As expected, the strategy x rate interaction was significant ($F(3,54) = 6.46, p < .001$), as was the strategy x serial position term ($F(7,126) = 3.33, p < .001$). Finally, the three way interaction of strategy x presentation rate x serial position was also highly significant ($F(21,378) = 2.57, p < .001$) indicating that the shape of the function obtained tends to alter with changes in presentation rate and that this is particularly

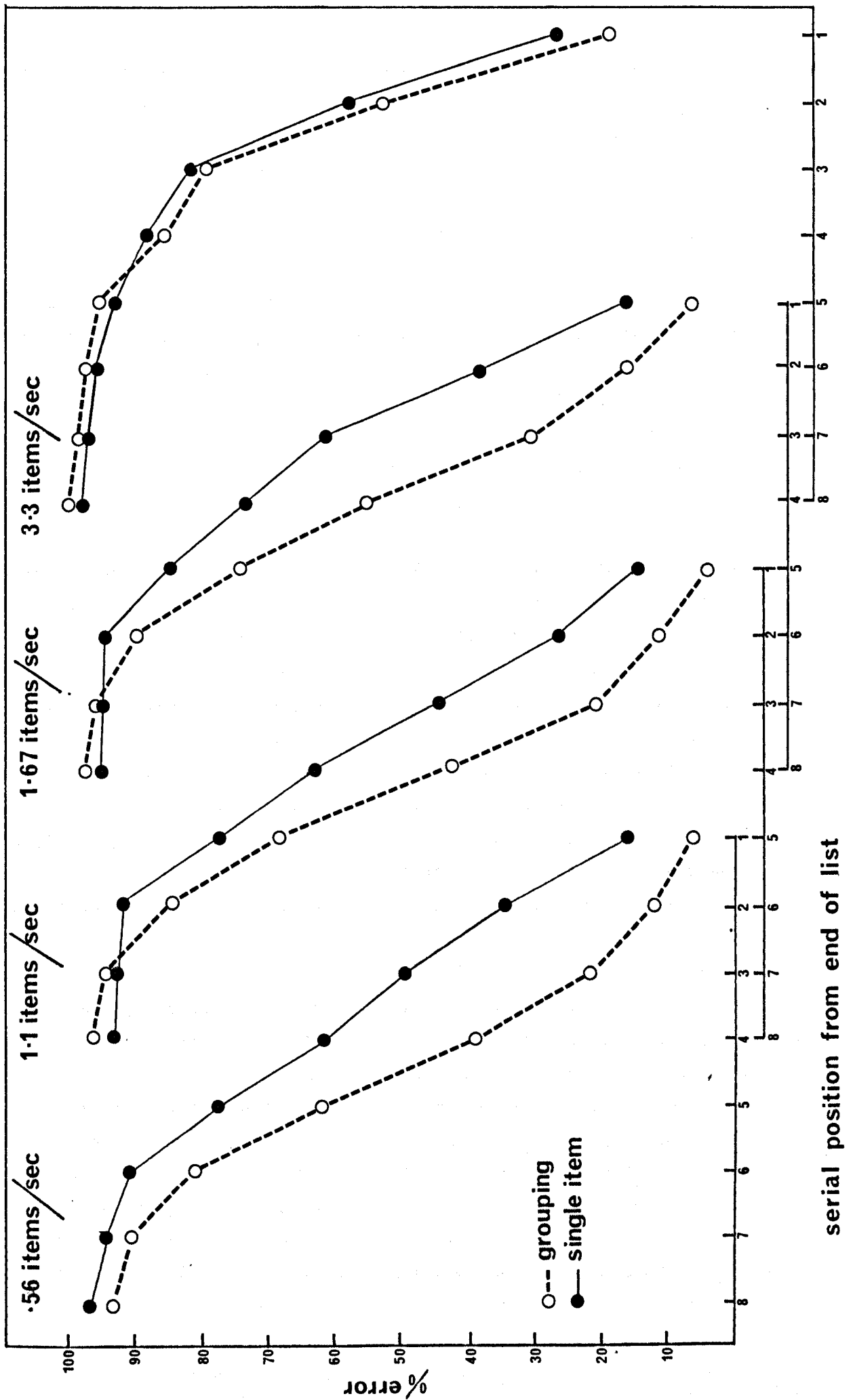


Figure 2:4 Percentage error scores for each serial position as a function of presentation rate for both grouping, and single item strategy conditions.

evident in the grouping strategy subjects at the fastest rate. No further interactions reached significance. The analysis therefore bears out the observations made from Figure 2:4 as regards the nature and locus of the effects.

Finally the post experimental debriefs were examined to ascertain whether or not the subjects felt that they had been successful in complying with the processing strategy they had been allocated. As expected the majority of the subjects in the single item strategy condition reported that the greatest difficulty was experienced at the slowest rate. Two subjects claimed that they were probably rehearsing in groups for most of the time under this presentation condition, while a further 2 admitted to grouping some of the time. Interestingly enough, of the remainder who reckoned they had faithfully complied with the instruction, although not without great difficulty, 2 subjects indicated that they became very bored as a result of not being able to rehearse items together. It is not clear therefore whether the apparently natural tendency to group items together is automatic in the sense that it merely utilises items which are somehow still present in conscious awareness, or whether it is simply an appropriate strategy in memory experiments which also removes a degree of tedium from the situation.

On the other hand, in the grouping condition, subjects claimed to be perfectly comfortable rehearsing the items in threes, except at the fastest rate. Indeed few were convinced that they were able to maintain the strategy throughout this condition, and when they did so they were aware of having failed to process further incoming items. Paradoxically, 2 subjects actually reported difficulty in carrying out the strategy at the slowest rate as well.

While it could not be maintained on the basis of these comments that each strategy was adhered to faithfully one hundred percent of the time, the debrief questionnaires would appear to contain sufficient evidence to justify the conclusion that a more consistent pattern was obtained than was achieved in Experiment 1. Only under the extreme conditions - the slowest rate for the single item group and the fastest rate for the grouping subjects - were severe difficulties encountered in maintaining the instructed strategy. These findings are important in drawing conclusions from the two experiments reported.

Before entering a general discussion of the data presented to date a brief summary of certain key features is appropriate. Firstly, it seems likely that the results of Experiment 1 represent the product of an adaptive system which capitalises on the opportunities afforded by decreases in presentation rate. This takes the form of more elaborate styles of rehearsal where items are encoded as groups rather than being

attended to in isolation. This strategy is apparently particularly enduring and is likely to occur even in the presence of a mild instruction to avoid such encoding patterns. (As such it therefore casts doubt on any experiment which seeks to avoid grouping rehearsal unless rigorous instruction and training are employed). When, however, both processing strategy and presentation rate are manipulated relatively independently of one another as in Experiment 2, both are shown to affect running span performance significantly.

Several questions require to be addressed concerning the implications of the results of Experiments 1 and 2. Not least amongst those refer to the relationship of the present findings to traditional recency and theories of the short-term store. Before entering fully into that discussion however it is necessary to dispose of one potential criticism which could be levelled at the data presented viz. that it could be modality specific.

2:5:1 Experiments 1 and 2 and Modality Implications

It will be recalled that both experiments employed visual presentation of the to-be-remembered material. Now while the existence of visual imagery as a cognitive process is acknowledged, it can be assumed that most similar STM experiments require the visual stimuli to be recoded into some speech-based format (see Crowder 1976 Chapter 4 for a synopsis of the evidence on this point). Thus having demonstrated effects of, for example, presentation rate on visual running memory span, it could be argued that these merely reflect benefits which accrue to this recoding operation at slower rates. Similar results therefore might not necessarily be forthcoming from an equivalent study using auditory stimuli where it can be assumed that this additional translation phase is not required.

Certainly it is a well-established fact that presentation modality has a marked and highly replicable effect upon recall of terminal items and takes the form of a consistent superiority for auditory material (eg Murdock and Walker 1969; Watkins 1972). Furthermore such effects are to be found in a variety of STM tasks and are evident whether the recall demands are unstructured as in the case of free recall (Craik 1969) or involve the production of serial order of input (eg Conrad and Hull

1968; Crowder 1970). Fortunately fairly direct evidence on this point comes from Hockey (1973). (In fact Hockey's study was conducted prior to the present series although the author was unaware of this until the much later publication date). Using an auditory running span task with random digits as stimuli, Hockey demanded recall of the last 10 items. Significantly, like the present Experiment 2, subjects were instructed to adopt an active (grouping) or a passive (single item) acquisition strategy. Broadly speaking, the main results were similar to those obtained by the author. The principal difference lies in the fact that Hockey (1973) found that recall under the passive condition tended to improve with increasing rate, and was superior to the active condition for the fastest rate (3 items/second). While the current results also show an advantage for the single item group (Figure 2:3, lenient criterion) at 3.3 items/second, this is not set within a context of improvements with increasing rate for this condition. Thus a complete description of the fine grain aspects of these results would require to address apparent differences between visual and auditory storage. In particular some appeal to a PAS type of mechanism (Crowder and Morton, 1969) seems necessary to explain any advantages which might accrue to auditory presentation under particular conditions which minimise decay (see Morton, 1970; p 230). On the other hand it can be assumed that all forms of active organisation of the input stream take time, and therefore increasing benefits from this strategy will follow decreases in presentation rate, regardless of presentation modality. Page 82

These comments notwithstanding, there is substantial agreement between Hockey's (1973) results and those of the present experiments, especially regarding the separation of strategy factors.

2:5:2 Implications for the Equivocal Results on Effects of Rate

Before going on to discuss the theoretical implications of these findings, it should be noted in passing that they have considerable potential value in helping to make sense of some of the conflicting evidence on the effects of presentation rate on short-term memory experiments. In the studies cited in the introduction, there was no direct control over the form of processing engaged in by the subjects. According to the present results, under such circumstances it becomes clear that the recall levels achieved will vary according to (a) the opportunities afforded for elaborate rehearsal strategies (where these opportunities are set by presentation rate); (b) the extent to which subjects make use of such opportunities; and (c) the degree to which order information is important in the task as such information apparently receives a proportionally larger boost from grouped rehearsals. Performance thus obtained at any one input rate will therefore reflect the nature of the operations carried out on the stimuli, and will be an amalgam of the rate and its consequent effect upon subjects' rehearsal patterns.

2:5:3 Implications for the Mechanism Responsible

It is now necessary to consider what underlying mechanism(s) may be responsible for the findings obtained for running memory span performance. It was argued earlier that running span could offer a 'purer' insight into memory for recently-presented material (than for example the recency component in free recall) given that the paradigm demands that only the most recent and therefore relevant information need be attended to at any one point in time. The results therefore will now be contrasted with other findings which purport to reflect memory for recent information in order to tease out the similarities and differences.

(i) The General Picture: Examination of the serial position analyses performed on the running span task (eg Figure 2:4) clearly shows that the functions obtained resemble the typical recency function. Recall is best for the last item and thereafter gradually deteriorates as distance from the end of the list is increased. The main difference of course is that whereas the recency portion in free recall is butted by the asymptotic level of the longer-term component, no such intersection

occurs in running span. This echoes Peterson's (1966) illustration of the two hypothetical functions operating in free recall.

(ii) The Effects of Memory Load: As reported in Experiment 1, alterations to the number of items required at recall affects the ultimate level achieved, such that more items are recalled under greater memory loads. This is perhaps hardly surprising as subjects are asked to recall more under conditions of high load. The point at issue however is whether the memory load results are compatible with theories based on free recall recency. In FR studies memory load (as represented by list length) has no effect upon recency (Murdock 1962; Postman and Phillips 1965). But in so far as subjects attempt to recall the whole list in such experiments, the entire recency portion is tapped - something which is arguably not the case in the low memory load conditions of Experiment 1. Indeed, scrutiny of Figure 2;2 tends to confirm that for load 4 one is only dealing with part of the story. Thus a simplistic comparison between the present results on load and free recall is perhaps slightly misleading and the fact that memory load affects the former, but not the latter situation, requires some qualification. The point can be made however that even for the very low load of 4 items, perfect performance is not achieved. This is despite the fact that such a figure is considered within the capacity estimates of primary memory as measured by some researchers (eg Baddeley 1970; Murdock 1972). To elaborate, one interpretation of the operation of PM in running span therefore would be to assume that the mechanism fills up to capacity (around 4) and with further presentations each new item displaces the oldest one held in store. As it can be assumed that there is no diversion of attention to any other items, the act of recall should be merely the dumping of the current contents of the store - the last four items presented. On the contrary however, the results argue for a graded loss of retrievability rather than the output from a fixed capacity 'perfect' store.

(iii) The Effects of Processing Strategy: The results of Experiments 1 and 2 taken together demonstrate quite clearly that processing strategy plays a significant role in running span performance. Different forms of processing affect both the shape and the level of performance achieved in the task. Two related conclusions can be drawn from these data. Firstly it seems clear that in the event of alterations to the presentation rate, the strategy adopted by the subject will change and will tend towards a form of grouping behaviour when there is sufficient time to perform such operations. Thus in the absence of direct control over such behaviours, performance achieved at any one rate will be confounded with the degree to which such encoding operations have been achieved. Secondly, when

such strategies are held relatively constant, then interactions with rate can still be expected to appear in the data. Such findings contrast with the views of the short-term store which emerge from recency-based theories. The latter do not readily admit flexibility; a more simplistic fixed capacity mechanism being central to the concept.

(iv) Effects of Presentation Rate: Although these have already been touched upon in connection with the processing factors noted above (with which they are intimately linked), certain observations require additional emphasis. For instance, even under conditions where elaborate rehearsal strategies can be assumed to be minimal (Experiment 2, single item condition subjects) presentation rate still appears to have an effect such that performance is better with slower rates. A second important aspect of this finding is that the improvements gained as a consequence of decreasing rate would not appear to be approaching any form of asymptote. That is to say that further gains in performance could be expected if rates slower than the slowest employed in the current studies were adopted. If performance in this task is considered to be reflecting the contents of some short-term store then this implies that the capacity of the system will expand and contract according to the rate of the incoming material. Such an account is clearly at variance with the majority of formulations of the modal model, although it does not necessarily preclude other explanations which will be discussed at a later stage.

Two final and related sets of comments should be made at this juncture. One is an attempt to counter criticisms which could be levelled at the present line of reasoning (which seeks to establish contrasts between the present findings and some of the more rigid conceptualisations of a short-term store) because it appears to ignore possible contributions from the so-called long-term component. The other relates to experiments using the free recall paradigm, where dramatic departures from traditional recency shape are encountered under conditions which appear to resemble, at least superficially, those of the present experiments. These are dealt with in turn below.

(v) Long-term Considerations: Thus far the argument has focussed on the effects of particular variables upon running memory span performance and has indicated how these are not paralleled by similar effects in free recall recency. One question which potential critics of this approach might be tempted to pose concerns whether any of the effects noted are the product of the long-term component. After all certain formulations of the modal model (eg Waugh and Norman 1965 and its derivatives) suggest that an item may be recalled from primary memory, secondary memory, or both.

Is it not possible therefore that increases in recall brought about by slow rates and group rehearsal strategies result from contributions from secondary memory which is assumed to benefit from such changes in these variables? Evidence against this position however comes from the serial position analyses conducted on both experiments. As pointed out previously, these functions show no stable asymptotic region except where scores begin to approximate zero or at least chance levels. This is seen most clearly in Figure 2:4 where performance under both processing strategies and all rates is virtually negligible for items furthest from the end of the list. In a similar vein Waugh and Norman (1965) argued that there was little likelihood of any long-term component present in their original serial probe study. In the parlance of dichotomous theories therefore, the effects observed in the present studies can only be viewed as the product of the short-term system.

(vi) Effects of Departures from Normal Processing Patterns upon Recency in Free Recall: While it is true to say (as has been pointed out repeatedly here) that the most prevalent feature of the recency effect is its invariance under all conditions except interpolated delay tasks (eg Glanzer and Cunitz 1966), there have been experiments which demonstrate dramatic departures from the traditional recency shape. Three particular studies can be cited as examples of this class of result.

Firstly for example, in an experiment designed to test the hypothesis that the number of rehearsals an item receives is directly related to its subsequent long-term retention (after Rundus 1971), Craik and Watkins (1973, Experiment 2) used a conventional free recall task but with instructions to pay particular attention to the last four items. In another condition the same instructions were administered but an unfilled period of 20 seconds followed each list during which it was assumed that processing of the terminal items would continue. Compliance with the instructions was verified by the rehearsal data which was collected in a manner similar to Rundus (1971). Both these conditions yielded correct recall probabilities in excess of .9 for the last four items in the list. Of greater relevance to the present discussion however is the fact that this represented a dramatic leap in the recall function. Indeed the recall for the item fifth from the end of the list was around the .3 level.

Essentially the same result has been reported by Shallice (1975). Using an auditory cue to indicate the onset of the last 5 list items, and instructions to focus particular attention upon terminal items, Shallice (1975) found that their immediate recall could be greatly enhanced relative to normal controls.

Perhaps even more directly related to the present data is a series of experiments conducted by Gianutsos (1972). Using pauses introduced into the presentation sequence after every 3 items as a means of inducing temporal grouping patterns she found improved recall over the recency portion of the free recall function. It is also instructive to note in passing that Gianutsos' (1972) data did not reveal a comparable benefit to the long-term component. This tends to support the earlier contention that what is being examined in all these studies, including those of the author, is strictly a short-term phenomenon.

The above studies therefore reveal that it is possible to produce sharp discontinuities over the recency portion of the immediate free recall curve as a direct result of changes in the processing afforded terminal items. It could therefore be argued that these findings are essentially similar to those obtained in Experiment 2 (grouping condition) in that the latter are also produced by requesting the subjects to maintain a strategy of grouping the terminal items. The point to be made however is that the results of the free recall studies noted above are brought about by deliberate attempts to alter the normal processing pattern engaged in during free recall. That they have succeeded in this respect is evident from the serial position curves obtained. They are not representative however of the normal situation. In contrast the running span Experiment 2 study was conceived on the basis of strong suggestive evidence emerging from the first experiment which indicates that the processing style did alter with the input conditions. Thus although Experiment 2 appears to separate artificially two processing modes, chosen to represent possible extremes along a continuum, this was a deliberate feature designed to tease apart suspected confounding effects. The situation under scrutiny therefore was one which already appeared inherent in the task, and was not artificial in the sense that it introduced forms of processing not normally engaged in. It is important to bear this subtle distinction in mind lest the running memory span results be trivialised by the mistaken impression that they show merely that performance changes when processing changes.

Having established that the task is predominantly one involving short-term processes in that there is no evidence of any durable component, and that it is affected by the particular variables noted above, it is necessary to examine whether any of the existing theories can handle these results adequately.

(i) Dichotomous Theories : Capacity versus Processing Limitations

Thus far the case presented has tended to argue against satisfactory explanation of the running span results in terms of most of the variants of the modal model. The principal reason for this stems from the apparent flexibility evident in the findings which is difficult to account for easily in terms of some fixed capacity storage mechanism. Admittedly it has been pointed out (eg Craik and Lockhart 1972) that there has been a degree of confusion within the dichotomous camp over whether the limit upon performance was one of storage capacity, processing capacity, or some unspecified interaction between the two. However it seems fair to claim that the Waugh and Norman (1965) model and its derivatives through to Glanzer (1972), plus the legion attempts to quantify primary memory documented in the theoretical overview of Chapter 1, all make the assumption that the limit is upon storage space within the system; and further that this can be measured directly in terms of the number of verbal units (cf Glanzer and Razel 1974). The present data however especially in the light of the effects of presentation rate and the direction of such effects, lean heavily towards an explanation couched in terms of limitations upon processing. This is seen particularly clearly in the results concerning strategy factors in Experiment 2. Contrary to the impression created up until now, this does not completely rule out all possible versions of the modal model. Indeed the notable exception is the specialised version of the general Atkinson and Shiffrin (1968) account which incorporates the operation of a rehearsal buffer. Of all the 2-store theories only that of Atkinson and Shiffrin actually incorporates a specific rehearsal mechanism within the formulation.

The model was developed originally to handle specific short-term memory tasks and was tested in one such paradigm: A continuous paired-associate task where a number of stimulus items are constantly repaired with different response terms. Under such circumstances, it is argued, there is little opportunity or reason to perform sophisticated encoding operations as only the current status of any S-R pair is required at recall. Indeed the task is obviously very closely related to the multi-source monitoring situations of Yntema and the others mentioned in the introduction. As such it is slightly more complex than the single source running memory span paradigm employed in the present experiments. Nevertheless all the tasks possess common features in that they require only current information to be processed.

A number of implications follow adoption of Atkinson and Shiffrin's (1968) model in this context. In the first place, in the running span task under conditions where several items are processed together (eg Experiment 2, Grouping Strategy) then this function will be carried out by the rehearsal buffer. As the buffer is considered capable of holding 2 pairs of items in the paired-associate task, then groups of 3 items should be well within its capacity. When the list ends and recall is required the current contents of the mechanism can be off-loaded immediately. Another assumption of the model is that every item resident in the buffer at the time of recall is reproduced perfectly, and consequently this operation should result in performance superior to conditions where the buffer was not employed in rehearsing groups of items (cf Experiment 2, single item strategy). This need not imply a sharp discontinuity in the function with the last 3 items in the grouping condition always being recalled with the probability of unity. Under conditions of different list lengths perfect divisibility by three's cannot be assumed, and even on occasions when this is the case it will depend upon how faithfully the subjects managed to maintain this pattern throughout fairly long lists. The results are therefore likely to reflect a certain superiority for the terminal items but with the function smoothed by a sort of averaging process.

One feature of the model however does not seem to be reflected in the running span data. This concerns the long-term registration of the items. According to the model long-term strength builds up as a consequence of residence in the rehearsal buffer. It is not clear whether this predicts that there should be evidence of superior long-term recall under conditions of group rehearsal, as residence in the buffer could have been equivalent in both strategy conditions. It does however require this to be the case when slower rates of presentation are in use, as these permit more time for rehearsal. Scrutiny of the data however reveals no support for this contention; performance at all rates, including the slowest, drops steeply and is virtually negligible for the last 2 or 3 items (ie. furthest from the end of the list). In this context it is also interesting to note that these functions appear different from the data produced by the continuous paired-associate task presented in Atkinson and Shiffrin (1968). Data from the latter show a sharp drop in performance between the last and the penultimate pair and thereafter a slow and steady deterioration as further item pairs intervene. Even after 17 intervening events however, the probability of a correct response is around .3 - a figure reached after only around 4 events in the running span task. Clearly then there are important differences between the two

tasks. Whether these are entirely responsible for the buffer model's inability to handle all such data is not immediately apparent; certainly there are limits to its generality even in situations for which it was designed. In conclusion therefore the buffer model of Atkinson and Shiffrin (1968) appears to offer a good general description of the data provided that assumptions concerning long-term storage are not adhered to rigidly. There would appear to be conditions where better short-term performance is attainable as a consequence of residence within the buffer, but where this does not automatically lead to more efficient long-term retention. Such a stance would have clear sympathies with those who wish to draw a distinction between different types of rehearsal and their effects upon recall (eg Craik and Lockhart 1972; Craik and Watkins 1973; Woodward Bjork and Jongeward 1973).

(ii) Alternative Accounts

The experiments reported were not conducted specifically to test between particular theoretical accounts. Rather they were conceived initially to provide another setting for the study of recency phenomena. Nevertheless the results should be examined against the background of alternative theories which have emerged since the experiments were carried out.

In this context it seems clear that the lack of any long-term effect encountered in the data would appear to be well-handled by any theory which stresses that one possible role for rehearsal is a maintenance-only function. Thus the levels of processing formulation of Craik and Lockhart (1972) and Craik and Tulving (1975) is particularly successful in coping with this aspect of the data. The nature of the task and its demands do not lend themselves to complex semantic forms of encoding and therefore any strategy which seeks merely to maximise short-term holding operations is the most appropriate. Having noted this however it is probably true to say that a more adequate description of the results is provided by the model of Craik and Jacoby (1975) which views recency as multiply-determined. Under their scheme, recency can be viewed as the product of one of three possible operations: Output from a primary memory; The product of a backward scanning operation; or the result of some reconstructive strategy. Of these, only the first two need be considered appropriate to the running span task. Thus under conditions where several items are being processed together as a group, these are considered to be maintained in a state of conscious awareness. At the time of recall therefore, these items are available in some form of primary memory for immediate output. Under conditions where grouping

is not practicable, either because the presentation rate is too fast or because such a strategy has been discouraged by instruction, recall will be likely to proceed on the basis of the backward scanning process. As this is limited in efficiency by the number of intervening items, performance will rapidly deteriorate as items further from the end of the list are attempted. Such a model would appear to offer satisfactory explanation of all the main features of the data. However it is not necessarily the only account which could be made to fit the results.

One other theory which, with some modification, could also explain the results is the working memory model of Baddeley and Hitch (1974; 1976). The main stumbling block in the present formulation of this account is the claim that recency is only the product of an ordinal retrieval strategy. It is therefore similar to the backward scanning process of Craik and Jacoby (1975) mentioned above, and as such is perfectly capable of handling the results from the single item strategy conditions. As it stands however the theory would appear to have difficulty in predicting the admittedly fine grain, but significant changes which accompany the grouping strategy conditions (whether natural or induced). Baddeley and Hitch (1974) do assume the operation of a slave rehearsal loop which works to serve the central executive of the working memory system. (In this respect the model clearly owes something to the Atkinson and Shiffrin (1968) model). If therefore the working memory theory were modified to permit the dumping of the contents of this loop - in much the same way as Atkinson and Shiffrin's rehearsal buffer operates - then the data could be accommodated.

Of the other major theories discussed in Chapter 1, none appears to offer sufficiently detailed prediction to handle the fine print of the running span situation. For example, the positional distinctiveness account does not appear to be concerned with changes which might result as a function of different forms of processing; items are either at the end of a list and are therefore distinctive, or they are not. A similar criticism could be levelled at the relative temporal discriminability account of Bjork and Whitten (1974) where only the items' positions in time are really important. In any case this theory disqualifies itself from possible explanation owing to the precondition of discrete rehearsal of each input event. It would therefore only be possible for the Bjork and Whitten (1974) theory to address the single item strategy condition results legitimately.

The research reported in this Chapter began by questioning the validity of conclusions concerning the hypothetical short-term store which were based on the recency component of the free recall task. These doubts were based originally on criticisms of the basic paradigm itself, and the fact that the majority of the researchers in the area appeared to be ignoring considerations of what the subject was actually engaged in while attempting to learn the lists. This somewhat blinkered approach it is argued, led almost inevitably to the identification of recency as the short-term store. Thus constrained by a highly replicable but extremely rigid result, the investigators were bound to arrive at extremely rigid models of short-term memory mechanisms and function. The probable reasons for this state of affairs are not difficult to comprehend. That the human organism is extremely limited in short-term memory function is a long-established fact; it is evident in everyday experience and has been consistently proven in laboratory experiments. The appearance of a function such as recency - an effect which only proved vulnerable to interpolated activity - was therefore all too seductive. Free recall recency was therefore seized upon as the direct empirical evidence of the mechanism responsible for short-term memory limitations.

The rationale behind Experiments 1 and 2 was completely different. Owing to evidence which highlighted the consequences of not controlling for input processing strategies during the acquisition of free recall lists, experiments were conducted with a running memory span paradigm where only recent and relevant information is presented and recalled. While the results indicate some marked resemblances with traditional recency - a fact that is not altogether surprising - they also reveal some important differences. These have been mainly in terms of operating flexibility in that effects of presentation rate and processing strategy were pronounced. This is not to deny that rigid limitations can and do exist within short-term memory function. What it does however is to change the emphasis from one of capacity limitations, to one of processing limitations.

Various theoretical models were examined in the light of this information, and accounts which tended towards storage limits were dismissed as being inadequate explanations. While the data could be accounted for in terms of the Atkinson and Shiffrin (1968) buffer model and the Baddeley and Hitch (1974) working memory formulation, both theories were found to be in need of modification. Also, while the data

did not contradict the levels of processing approach in any major respect, the best account of the data seemed to be provided by the framework of Craik and Jacoby (1975) which views recency as the outcome of more than one type of process.

The argument advanced here, although not explicitly stated to date, is one which essentially regards 'traditional' recency as something of an artifact of the free recall paradigm - an important phenomenon undoubtedly, and one which requires explanation - but not something which has to be regarded as the literal evidence of a short-term store. Theories based on this assumption are therefore questioned by the present results. The remainder of this investigation will attempt to unravel some of the mysteries surrounding the recency effect in its more traditional setting.

CHAPTER 3

THE INFLUENCE OF EXTRANEOUS (NON-MEMORY) MATERIAL: UNIDIRECTIONAL EFFECTS OF CLASS SIMILARITY AND BI-DIRECTIONAL EFFECTS OF ITEM IDENTITY.

- 3 : 1 PREFACE
- 3 : 2 GENERAL INTRODUCTION
- 3 : 3 EXPERIMENT 3 : EFFECTS OF VARYING THE CLASS OF DISTRACTOR
 MATERIAL I : POST LIST DELAY
- 3 : 4 EXPERIMENT 4 : EFFECTS OF VARYING THE CLASS OF DISTRACTOR
 MATERIAL II : PRE-LIST 'DISTRACTOR'
- 3 : 5 GENERAL DISCUSSION OF EXPERIMENTS 3 AND 4
- 3 : 6 GENERAL SUMMARY OF CHAPTER 3

One of the major concerns of the previous chapter was the effect of the 'type' or 'degree' of processing afforded items in a particular short-term memory task where the interest was focussed exclusively upon recall of very recently presented material. Although only some of the list items were required at recall, the nature of the task demanded that all incoming items were processed in the same way. This section is likewise concerned with only partial recall of an input stream of stimuli, but in contrast to Chapter 2, under circumstances where the subject has foreknowledge of which items constitute the critical memory set. Thus the situation being examined is the effect of processing extraneous material (which has to be monitored, but not retained), upon the recall of a to-be-remembered list. Two principal aims can be identified in the experiments to be reported. The first was to examine the effects of categorical/class similarity between the to-be-monitored and the to-be-remembered stimuli. The second aim was to determine the direction of influence of any effects produced by the 'irrelevant' activity as they could be inferred from having it follow (post-list delay), or precede (pre-list distractor), the memory string. Once again particular attention will be paid to serial position functions as a means of defining the locus of any effects obtained.

The running memory span paradigm employed in the experiments described in Chapter 2 is an extremely demanding task. The main source of difficulty derives from the uncertainty during presentation over which items are critical to recall. This in turn dictates a requirement for sustained attention and continuous processing of all incoming material as any lapses could result in vital items not achieving any form of storage status. However it should also be noted that a further difficulty might be encountered at the recall stage. While this problem was not examined directly in the experiments reported, the possibility of some form of competition during retrieval clearly exists. Briefly this comes about for the following reason. Although at any one point in time during presentation of a sequence attention is likely to be devoted to rehearsing only the 'current' set of critical stimuli, obviously similar efforts were directed at storing previous items. Therefore it could be argued that when the list ends, subjects have to retrieve the relevant events against a potentially noisy background of similarly-processed material. In comparison this chapter questions whether material which is merely monitored during a classification task but not 'learned', has any effect upon the recall of a set of memory items. In this first section, the influence of a classification task which follows the memory list (like an interpolated distractor activity) will be studied. However as the paradigm is 'reversed' during the second section of the chapter to allow the monitored list to precede the memory list, clearly a return to the recall of fixed-length lists is demanded.

3:2:1 The Effects of Similarity: I : Relationships between Memory Stimuli

The literature contains a number of examples of studies on the effects of the nature of the stimulus material upon subsequent retention where this is both in the short- and long-term. One group of such investigations was concerned primarily with the question of whether the two hypothetical memory systems (primary and secondary memory) could be differentiated on the basis of the coding operations they employed. In particular the question which tended to occupy attention for several years was whether phonological encoding was employed in primary memory while semantic encoding was the case in secondary memory. Thus experiments were conducted where the phonological and semantic similarity of the material to be learned was varied.

For example Baddeley and Dale (1966) employed a variation of a paired-associate task which conformed to the pattern - Learn List A, Learn List B, test List A. The main feature of this study was that in the experimental condition the stimulus terms in both lists were highly similar in terms of their meaning. Control lists on the other hand contained no such relationships. In one condition (designated the long-term condition) the lists were composed of eight pairs and learning was conducted over eight trials. In another, (the short-term condition) only two or three pairs made up each list and these were only presented once. The results were fairly clear cut. In the long-term condition the semantic similarity between the stimulus terms reduced performance drastically relative to controls. In the short-term condition however, while there was still a tendency for controls to perform better, the effect was now extremely small.

A similar conclusion can be drawn from further experiments by Baddeley (1966a) using 10-item lists containing either phonologically similar or semantically similar stimuli. When an interpolated digit coping task was introduced between presentation and recall it was noted that it was the semantic similarity which affected performance. Under conditions of immediate recall however, the opposite was the case and phonological similarity was shown to interfere with performance.

Further supportive evidence for this distinction comes from studies by Kintsch and Buschke (1969) using the Waugh and Norman (1965) serial probe technique, and Tell (1972) who employed a Brown-Peterson task. The case was thus established for phonological coding within the short-term component and semantic coding within the long-term component. Also, as much of this evidence was produced at around the time when support for the dichotomous view was growing it became immediately absorbed within the framework of justification for the two systems.

The position has not gone entirely unchallenged and a series of experiments by Shulman (1970; 1972) presents persuasive evidence of some semantic information within the primary memory component. The paradigm adopted (Shulman 1970) involved a probe-judgment task following presentation of a 10-item list. When given the probe the subject had to make one of three decisions concerning its relation to any of the words in the list viz. (i) whether it was identical to any item, (ii) whether it was a homonym of any item, or (iii) whether it was a synonym of one of the list members. The results were scored both for the proportion correct and for the reaction time to arrive at the decision. While it was clear that the number of correct decisions for both the identical and homonym questions was virtually the same, especially over the recency part of the function,

and that both of these were superior to the synonym questions over the entire curve, the form of the curve for the latter was of essentially the same nature and merely seemed to have been lowered by an amount which varied between about 5 and 15 per cent. In the reaction time data, all three functions were separated with identical judgments being fastest, homonym judgments next fastest and synonym decisions being slowest. However once again the shape of all three functions was the same with faster reaction times being recorded for later (recency) items. Shulman's conclusion from all this is that there is definite evidence of semantic information in primary memory.

Baddeley (1972) has argued that there may be another interpretation of these data. His argument assumes that on being confronted with the probe, the subject generates an appropriate item and then compares this with phonological traces left by the list. The speed of the reaction times observed in Shulman's (1970) study however demand that any such semantic-generation and subsequent trace-comparison processes would require to operate extremely fast.

It should be noted that it would not be totally damaging to dichotomous positions to admit to some semantic information being present within the recency component. After all, a number of the models assume that an item could be represented in both stores (eg Atkinson and Shiffrin 1968; Glanzer 1972). However the situation is not solved by such an admission as it still implies that phonemic coding will predominate over terminal items - a position which is further strongly challenged by results which show no detrimental effects of phonological similarity in the recency portion of free recall (Watkins, Watkins and Crowder 1974).

Thus in conclusion, while there were good grounds initially for assuming that the early work by Conrad (1964) on acoustic confusions would be refined into indicating a coding system which was the exclusive property of a primary memory mechanism, further work has tended to cast doubt on such an interpretation. Clearly some relaxation of the position is necessary if the above results and other contrary evidence (for example, indicating the presence of short-term visual coding factors - Posner and Keele 1967) are to be included in the scheme. One way of achieving just such a compromise proposed by Atkinson and Shiffrin (1968) was to assume that the short-term store could be subdivided into a series of sub-stores (auditory, visual, kinesthetic etc.) corresponding to the different and specific forms of encoding operations which could be engaged.

3:2:2 The Effects of Similarity : II : Relationships between
Memory and Non-Memory (Distractor Activity) Material

3:2:2:1 Delay Tasks

(i) The Basic Retroactive Result: Before entering into discussion on the possible effects of similarity in this context, it is necessary to establish some basic facts concerning what occurs when a subject is required to perform some additional task following the presentation of to-be-remembered material and before being permitted to attempt recall. In accordance with the typical result, which reveals that performance on the memory material is worse than that on control lists which were not followed by such activity, this task was originally dubbed as the 'retroactive inhibition' paradigm. Such a label is intended to convey the general nature of the findings by indicating that the interpolated activity appears to have a detrimental effect, and moreover appears to be exerting an influence backwards in time. While ideas concerning the phenomenon have been somewhat refined since the rather crude statement above, the retroactive label is still frequently used to refer to the basic experimental result.

(ii) Interpolated Task Difficulty: While the general statement that some interpolated activity has an adverse effect upon recall is certainly true, it is also clear that the nature of the activity is important in determining the extent of this effect. The point is illustrated in experiments reported by Posner and Rossman (1965) using varying levels of interpolated task difficulty, although a similar case had been advanced earlier by Pillsbury and Sylvester (1940). In one experiment Posner and Rossman (1965) presented 8-digit lists to subjects who were required to perform various types of transformation on any except the first two digits. In ascending order of difficulty (as measured by the amount of information reduction involved) these transformations were (i) writing down a pair of digits in reversed order; (ii) adding two adjacent numbers together and recording their sum, (iii) classifying each pair of numbers as being either above or below 50; and (iv) classifying as 'A' any pair which is high and an odd number, or low and even, and as 'B' when the reverse is the case. Scoring was done by measuring only the recall of the first 2 (untransformed) digits of the series. The total number of errors recorded for the above four conditions of interpolated activity were respectively (i) 129; (ii) 266; (iii) 264; (iv) 292, showing clearly that the degree of difficulty significantly

affected retention. Further experiments within the same series (Posner and Rossman 1965) showed that these effects of distractor task difficulty were maintained over a range of retention intervals from 0 - 30 seconds.

The explanation advanced for these findings is that the more involved the interpolated activity, the less attention can be devoted to processing the necessary items. Such an account is clearly in keeping with the results of studies employing concurrent tasks which have to be performed at the same time as the memory items are being presented. For example, Murdock (1965) found that recall deteriorated as a function of the difficulty of a simultaneous card sorting task. It should be noted however that, by their very nature, these statements appear to implicate limitations of processing rather than those of storage.

Exactly this point is made in an experiment by Dillon and Reid (1969). Using a Brown-Peterson paradigm and a procedure which closely followed that of Posner and Rossman (1965), these authors had subjects process digit pairs during the retention interval. Two levels of difficulty in this task were employed: (i) an easy task which merely required reading each digit aloud, and (ii) a difficult task where the digits had to be added and their sum classified as odd or even. The result of interest to the present discussion was that when both levels of interpolated task difficulty were included in the retention interval, recall of the memory material was better when the easy task came early in the period, and worse when the difficult task occupied such a position. The implication of this result is that some additional processing of the memory material is likely to take place following presentation, and that only a sufficiently demanding activity is likely to halt this process.

In drawing this section to a close therefore it can be assumed that the results indicate that the greater difficulty of the distractor task, the more deleterious the effect upon retention of the earlier memory string.

(iii) Effects of Similarity: In the same way as a previous section documented an interest in the study of both semantic and phonemic similarity effects within to-be-remembered material, studies involving distractor materials have also manipulated these variables and detrimental effects attributable to both forms of similarity have been found.

Thus Neimark, Greenhouse, Law and Weinheimer (1965) used CVC trigrams of either low or high association value and retention intervals of 0,3,9 and 18 seconds. During the interval subjects were required to spell aloud

nonsense syllables of high, medium, or low association value, or 3-digit numbers. Best retention was achieved for high association CVC's and this seemed hardly affected by any similar interpolated activity. On the other hand, low association value CVC's were detrimentally affected when similar low association material made up the distractor activity. This study is however open to criticisms concerning the disparate initial levels of difficulty involved in learning the two types of material.

Such a criticism cannot be levelled at a study by Corman and Wickens (1968) who make a similar point using a somewhat different design. Subjects were instructed to attend to a 20-item series where most of the items would be digits. Positions 4, 5 and 6 in the stream were always consonant letters which had to be memorised for report at the end of the list. The crucial feature of this experiment concerned what items were actually included in the series following position 6. In the control condition all subsequent items were in fact digits. However in the two experimental conditions, two further consonants were substituted, either close to (positions 9 and 10) or far from (positions 17 and 18) the memory items. The results were clear cut : The presence of additional items belonging to the same class as the to-be-remembered items reduced recall performance. Further, the results contained suggestive evidence that this effect was more damaging the earlier the similar material appeared in the series.

While the above experiments testify to the harmful effects of semantic or class similarity, comparable effects have been obtained for phonological similarity. Using a Brown-Peterson paradigm Wickelgren (1965) observed that memory performance on a series of consonant letters was an inverse function of the number of similar sounding letters included in a post-list copying task.

(iv) List Recall and Delay Tasks: The foregoing sections document the harmful effects of interpolated activity and further indicate that such effects are increased when the material in both memory and distractor tasks is similar either along a phonological or a semantic dimension. What they do not do however is provide any clear insight into whether, for example, these variables interact with serial position. While this is hardly surprising considering that the paradigm adopted in most cases has been the Brown-Peterson task, the omission of suitable experiments would seem to be important in the light of recent attention devoted to a componential analysis of STM function. In this respect, consideration of the relationships between memory and non-memory distractors appears to have lagged behind (or been discouraged by) the attempts to find evidence of exclusive coding operations which characterised so much of the study of within-list relationships (see Section 3:2:1).

It will be recalled from the discussions in Chapter 1 that one of the most influential findings in the context of the debate on 2-store approaches was that when presentation of a free recall list was followed by an irrelevant task, recall of terminal items suffered most (Postman and Phillips 1965; Glanzer and Cunitz 1966). However following the result that a period of backward counting eliminated the recency effect, little sustained effort appears to have been devoted to exploring the possible effects of different types of distractor activity. What little evidence exists suggests that some forms of class similarity between memory and distractor are harmful to retention. Thus memory for verbal material is more vulnerable to the effects of interpolated verbal activity than a task involving tone detection (Keitman 1974), and conversely, memory for a series of tones is more susceptible to a series of interpolated tones than one of numbers. What is still not entirely clear however from results such as these is whether the effects are truly confined to a restricted locus within the serial position function. Virtually the only study which has co-varied both phonemic and semantic similarity between memory and distractor tasks in free recall has been an experiment conducted by Glanzer, Koppelaar and Nelson (1972). These authors used a four-word post-list distractor task which had to be read out following presentation of the free recall list. The main conditions of interest were where the interpolated material was either semantically or phonemically similar to the memory material. On the basis of their results Glanzer et al claim that neither manipulation had any differential effect upon terminal item recall which merely suffered in the usual way from being denied immediate output. (It should be noted however that in their experiment recency was reduced but not eliminated, a finding which could be interpreted as being indicative of an insufficiently demanding distractor which might not have fully prevented further processing of the memory items). However the author is unaware of any other studies of this type, and it would seem prudent to avoid firm conclusions on these issues until more data becomes available.

(v) Conclusions on Post-list Distractors: In summary therefore, while there is some evidence to suggest that certain types of similarity between the material in the delay task and that of the memory stimuli is detrimental to recall, there is very little in the way of definitive evidence to substantiate the claim that such effects are confined to pre-recency portions of the serial position function. However what little data exist from studies employing controlled manipulation of relationships between distractor and memory materials tend to confirm the results of all

other standard delay experiments in concluding that the recency effect is removed, but that any further differential effects are more likely to appear over earlier portions of the serial position function.

If the situation with regard to similarity effects noted above has been characterised by a paucity of definitive experimentation, it must be noted that one class of similarity has been ignored altogether : That of 'identity', or where both memory and distractor lists contain exactly the same material. This observation is not nearly so outrageous as it may appear at first sight. For example, a number of recent experiments have shown that the recency effect which is normally removed by the imposition of a period of activity inserted between presentation and recall, can in fact be 'reinstated' if further distractor periods are interspersed between all the list items (Tzeng 1973; Bjork and Whitten 1974). By analogy with these results therefore, one might reasonably question whether a similar finding might not be obtained when the list material is repeated in the form of a delay task. Certainly conventional 2-store models which view recency as the all too vulnerable output from STS would not anticipate such a finding, but by the same token, they are unable to explain the long-term recency effects noted above. This question will be returned to in due course. For the moment attention will be turned to another apparently neglected area : That of the pre-list distractor paradigm.

3:2:2:2 Pre-List 'Distractors' :

A substantial body of evidence testified to the effects of prior learning upon the recall of subsequent learning. Indeed the situation has been one of the most consistent focuses of attention within the study of interference effects and memory performance. Within this context, the phenomenon of proactive inhibition (the other side of the coin from retroactive inhibition) is well established, and indicates that there tends to be a progressive deterioration in recall performance over the first few trials in a series. Furthermore, and of particular interest to the present discussion, there are clear indications that class similarity across the learning trials in this paradigm plays a vital role. This can be deduced for example from a study by Wickens, Born and Allen (1963) who demonstrated that 'release' from the harmful effects of PI can be achieved when the class of the memory material is altered during the learning series. These results have been amply replicated notably in a set of experiments reported by Wickens (1970). Thus from

all this it can be concluded that the phenomenon of PI is well established, and further that it appears to be fairly dependent upon similarity relationships amongst the material to be learned. Once again it must be pointed out that insufficient work with lists, as opposed to Brown-Peterson items, has been conducted and consequently the debate still continues over whether the effect resides within primary or secondary memory (see Crowder 1976).

However, all of this research effort has been directed at examining the effects of prior learning upon subsequent learning. In this respect the work has possibly more in common with the research on relationships between memory stimuli discussed in section 3:2:2. Little or no attention has been paid to the possible effects of different forms of processing which are not directed at storing material upon the learning performance in a subsequent memory list. Once again, this appears to constitute a fairly serious omission, as no real information exists to evaluate exactly what forms of processing in prior tasks are likely to affect subsequent learning detrimentally. Moreover from a theoretical point of view the sort of paradigm being suggested would appear to offer a further appropriate vehicle for examining predictions from a levels of processing approach (Craik and Lockhart 1972). That is to say that to the extent that control can be exercised over the nature of the encoding operations performed during a pre-list distractor task, predictions concerning the likely memorability of such material should be feasible. This in turn might be likely to lead to conclusions concerning their potential influence upon subsequent to-be-remembered items.

In addition the type of task being outlined would also appear to offer some form of test of the positional distinctiveness account of serial position effects in short-term memory (eg Murdock 1960). Thus while the conventional delay paradigm depicts the removal of recency and the survival of primacy (findings in line with such an account) no comparable work appears to have checked whether the converse is true under circumstances where the distractor precedes the memory string. Furthermore, variations in the class of material contained within the two tasks would appear to open up the question of whether such primacy salience is dependent not only upon its privileged position but also upon its conceptual distinctiveness.

Finally, the pre-list distractor paradigm might provide a suitable method of obtaining 'primacy effects' in the absence of differential rehearsal (eg survival of the early portion of the distractor). Other research has sought to establish such a case (eg Hockey and Hamilton 1977) but as the studies used to-be-remembered material, explanations of obtained primacy based on differential encoding cannot be excluded. The proposed experiment, involving material which is not to be retained, would not be open to such criticisms.

In conclusion therefore several gaps in the existing literature have been identified as offering further critical examination of the effects of recency and primacy in memory list analysis. The prime areas where experiments appear to be indicated can be summarised as concerning:

- (i) The effects of a post-list distractor task where the relationship of the material comprising the irrelevant activity to that making up the memory list is varied along a dimension of class similarity;
- (ii) The effects of a pre-list distractor task under the same conditions as that outlined above, and
- (iii) The extension of the similarity concept to include features of 'identity' between the distractor and memory material.

A few brief comments on the theoretical implications of these issues are appropriate at this point.

3:2:4 Theoretical Predictions

At this point it is necessary to outline briefly the nature of the distractor task envisaged for the experiments to be described. On the basis of the foregoing sections, and given that there should be no overlap between this and past work conducted on the effects of learning one set of stimuli upon the attempts to learn another set of items, clearly the distractor activity selected should in no way dispose the subject to memorise the stimuli it contains. On the other hand as part of the concern is directed at relationships of class, the material must evidently be processed to the post-categorical stage. A straightforward task meeting both of these conditions would appear to be provided by some form of classification activity. For example if the subject is instructed to monitor a stream of alpha-numeric items with a view to detecting merely the presence, or absence, of a digit in a stream of consonants (or vice versa), then one can assume that a decision regarding the categorical identity of each item has to be performed, but where there is no need to attempt to memorise any of the individual items themselves. Furthermore, if the memory material is held constant by only including letter stimuli, and the distractor is varied between lists containing predominantly digits and predominantly letters, then the effects of class similarity between the two can be explored.

(i) The Modal Model: Under circumstances where the distractor activity follows a memory list, thus preventing immediate recall, versions of this theory are bound to predict the removal of the recency effect, the contents of the short-term store being overridden by the subsequent activity. While this would be predicted regardless of the nature of the subsequent material, items of the same class as the memory list would probably be likely to affect earlier portions of the curve as well i.e. that part assumed to reflect semantic and long-term factors. Where memory and distractor material are identical, some additional benefit might be expected to offset this decrement owing to the extra 'rehearsals' the items receive but this would not be likely to restore recency to its immediate recall level. The position with regard to pre-list distractors is somewhat different. As the 'irrelevant' material is not to be rehearsed and memorised, only those models which assume that some registration in LTS will occur automatically (eg Atkinson and Shiffrin 1968) could predict any storage status for these items at the time of the presentation of the memory list. Even here however it is unclear whether such minimal acquisition would be likely to have any effect upon the memory list.

(ii) Levels of Processing: At first glance, a levels approach seems ideally suited to offering predictions concerning the possible influence of one set of stimuli processed in a particular way upon another set where a different set of encoding operations is required. However one immediate difficulty is encountered when attempting to assess exactly what 'level' of encoding operations is involved in the classification task selected for the distractor activity. On the one hand it could be argued that the nature of the judgment required is undoubtedly semantic in the sense that a decision concerning categorical class is demanded. By the original Craik and Lockhart (1972) formulation this would appear to predict the durable registration of distractor stimuli. On the other hand, the distractor material is hardly likely to be elaborately encoded because of the nature of the task demands. Thus according to the Craik and Tulving (1975) position these stimuli should not acquire particular memory strength. These comments however illustrate a frustrating difficulty which derives from the lack of specificity with regard to classifying encoding operations. Other examples of this type of problem could be cited as further evidence of the seriousness of such a limitation. (cf for example Johnson and Jenkins (1971) with Mandler and Worden (1973) where the same task of determining parts of speech was considered as nonsemantic and semantic respectively).

One is presumably on firmer ground if one assumes that whatever the nature of the processing operations performed upon the distractor stimuli, some form of trace at least will be laid down. This follows from the assumption that any encoding operation engaged in will result in some evidence concerning the item being potentially available, and appears to be borne out by the incidental learning studies cited in support of the model. Just how much evidence however, and whether it is likely to be sufficient to influence the memory list is not so clear.

(iii) Alternative accounts: It was mentioned previously that the pre-list distractor paradigm might offer some test of a positional distinctiveness account in so far as the primacy salience of the memory list might be blurred by preceding stimuli, especially where these are drawn from the same conceptual category. The situation with regard to the post-list distractor paradigm is unlikely to provide any additional information on this account beyond what is already known. It does however provide a potential test of one of the assumptions inherent in the Craik and Jacoby (1975) account of recency. These authors claim that items in episodic (Tulving 1972) or proximal memory are more likely to be harmed by the presence of other similar items to which attention is diverted. This would imply that post-list distractors containing material of the same class as the memory stimuli would have a more deleterious effect than those containing more neutral items. Such a prediction of course is not readily distinguished from that based on versions of the model model, unless the effects occupy different loci on the serial position function.

3 : 3 EXPERIMENT 3 : EFFECTS OF VARYING THE CLASS OF DISTRACTOR
MATERIAL I : POST-LIST DELAY

3:3:1 Method

Stimulus Material and Construction of List Conditions.

Vowels having been excluded, a series of 24 9-item lists of random consonants were constructed with the constraint that no list should contain any repetitions. Of these, 4 served as control lists for immediate recall, 2 as practice lists for the delay tasks, and the remaining 18 as the main experimental condition lists. Within these 18, 8 were followed by a 'digit delay' list and 8 by a 'consonant delay' list. These lists were also 9-items in length and were similarly constructed according to a sampling without replacement principle from either the consonant or digit pool. In four of the digit lists a single consonant letter replaced a number in either the 2nd, 4th, 6th or 8th position. Similarly in four of the consonant delay lists a single digit was included in the above positions. These inserted members of the opposite class of material were to serve as critical 'target' items which the subject would attempt to detect during the retention interval. Each memory list was paired randomly with a distractor, and the further constraint was imposed that no distractor should contain any item already present within the preceding memory string. The remaining two lists not so far covered by the above design were special variants of the consonant delay condition. In the first of these, and contrary to the constraints noted for previous conditions, the delay list contained the same consonant letters as the memory list it followed, although their presentation order was randomised (the repeated-random condition). In the second variant the same consonant letters were present in both memory and delay lists, and this time the input order was the same in both cases (the repeated-identical condition). Because of their special nature, these two conditions were always presented as the penultimate and last lists respectively (i.e. lists 17 and 18 in the experimental series). For obvious reasons neither of these distractors contained a 'target'. The order of presentation of the constructed lists was thus as follows : 2 control lists for immediate recall, 2 practice lists for the delay situation, 18 experimental lists, and finally the remaining 2 control lists.

The lists described above were compiled into four different sets whereby the memory lists in the experimental conditions were held constant, and the distractor lists were rotated. The purpose of this was to ensure that, over the course of the experiment, each memory list was followed by a digit delay with and without such an event. At the same time different

examples of the repeated-random and the repeated-identical conditions were constructed.

Each of the above four sets of lists was recorded on a Ferrograph tape-recorder for later auditory presentation. Each list was recorded at a constant rate of one item per second. The memory lists were spoken by the author, and the delay lists which followed them, without alteration to the one second rate, were spoken by a female voice. It was assumed that the switch in voice would be a sufficient cue to the change in the task demands between memory and distractor lists. Each list was preceded by the word 'ready', and followed by a period of 20 seconds for written recall.

Briefing and Procedure

All subjects were thoroughly instructed on the task prior to testing. During this period a further set of prerecorded lists was played to them containing examples of the principal conditions of control, digit delay, and consonant delay lists. This was done to familiarise them with the task, the method of presentation, and the two voices used during the recordings. They were instructed to memorise only the first set of items, which would always be spoken in the male voice, and would always contain consonant letters. When the voice switched to that of the female however the task became one of listening to a set of either consonants or digits for the presence of a member of the opposite class of material. They were instructed that the delay list could contain 0, 1 or 2 such targets. (In fact on no occasions did the delay task ever contain two targets; this information was only given to the subject to ensure that they continued to attend to the distractor material until the end of the list). These targets were never to be memorised, only their presence or absence noted. Only when presentation of the entire list was complete (i.e. memory plus distractor) were subjects permitted to begin their written recall on a sheet provided for the purpose. Boxes corresponding to the nine items in each list were drawn up on this sheet, and subjects were asked to place each item in its correct position in the sequence where this was known, although which order they chose to output the items was a matter of personal choice (ordered free recall). Finally on the response sheet, one final box was drawn beside each list. This was subdivided into three marked 0, 1, 2, and was provided for the recording of the detection decision. This was only to be done after recall had been completed.

Subjects

Forty students from the University of Stirling Part I Psychology Course acted as subjects in the experiments. All received a course credit for their participation. They were assigned randomly to one of four groups of 10, corresponding to the four sets of recorded lists, and were tested in groups of up to 10 at a time.

3:3:2 Results and Preliminary Discussion

Scoring Methods

Firstly it is clear that subjects attended to the distractor material as instructed, as performance on the 'detection' task was virtually perfect for all subjects. The raw data from the memory lists (ignoring the two practice conditions which were discarded from the analysis) were scored according to both lenient (without regard to order) and strict-order criteria. Most attention however will focus on the latter.

Serial Position Analysis and the Effects of Delay

With the exception of Lists 17 and 18, scores for all lists followed by consonant distractors (regardless of target content) were then pooled, and a similar operation was performed upon lists followed by digit delays. The results of a serial position analysis performed according to strict-order scoring can be seen in Figure 3:1. The upper panel depicts performance for the control (immediate recall) and the digit delay, and standard consonant delay conditions; while the lower panel shows the functions for the special consonant delay conditions of repeated-random, and repeated-identical. The first observation which can be made from this figure is that the control condition shows evidence of slightly lower recency than might be expected from, for example, that obtained in free recall. This could be partly due to the ordered scoring technique and partly due to the lack of control over output order. Nevertheless the immediate recall control is clearly superior to the standard delay conditions, and as might be expected on the basis of other evidence, this is particularly the case for terminal item positions. It was not felt necessary to subject this to statistical analysis to confirm the effect.

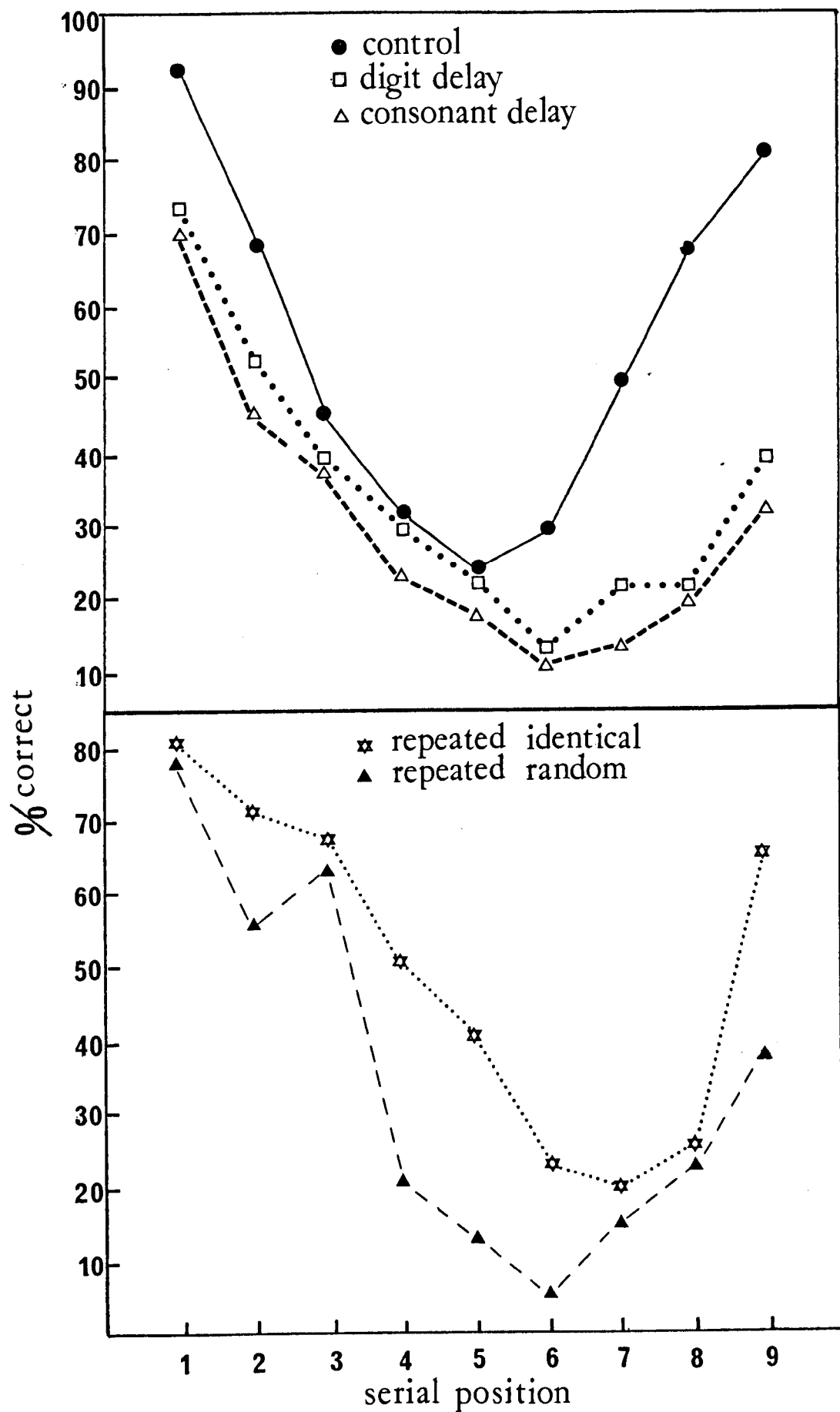


Figure 3:1 Serial position functions for immediate recall controls, and all post-list distractor conditions

The Effect of Similarity

Of the other experimental conditions, the upper panel of Figure 3:1 shows that performance on lists followed by digit delay tasks is superior to that on lists followed by consonant delay lists. In order to test this effect each subject's total scores for consonant delay and digit delay lists (now pooled over serial position) were submitted to a Wilcoxon matched pairs test, using the formula for large samples. This revealed that the difference between the conditions observed in Figure 3:1 was significant ($T = 201.5$, $(N=38)$, $Z = -2.45$, $p < .05$ two-tailed). It can therefore be concluded that a post-list distractor containing the same class of material as the preceding memory list will have a more harmful effect upon recall of that list than a distractor containing items of a different class. Furthermore, according to Figure 3:1 this effect seems to be relatively constant across all serial positions.

The Effect of Identity

The other conditions of interest are the special cases of consonant delay lists where the distractor contains the same items as the memory list. Serial position curves for these are presented in the bottom panel of Figure 3:1. Comparison with the other distractor conditions in the upper panel immediately reveals that presenting the same stimuli in both lists elevates performance over conventional delay procedures, and that this is particularly true for pre-recency portions. Indeed when the repeated-random condition scores for each subject are compared with his average performance on the digit delay condition lists a Sign Test reveals 18 scores in the + direction, 19 in the - direction, and three tied scores. Clearly therefore these conditions are indistinguishable. Thus the effect of a post list distractor containing the same items as the memory list but where their order is different, is to reduce the detrimental effect of class similarity and render performance comparable to conventional delay conditions. ^{The equivalence of these conditions however may be fortuitous.} (Note that for this test and others to be described below, scores in the repeated-random and identical conditions are based only on one list per subject, and therefore have to be compared against the average list performance under the other conditions. Such a procedure seems inevitable given the nature of the experiment, and in any case it seems likely to bias any test against the special conditions where the variance is likely to be higher).

Moving on to consideration of the repeat-identical list condition Figure 3:1 now indicates that performance is vastly superior to all other distractor conditions. Statistical confirmation of this comes from two tests performed on the data. The first, comparing the repeat-identical

scores for each subject with average performance on the consonant delay reveals that these are significantly different from each other (Wilcoxon $T = 111.0$, ($N=39$), $Z = -3.89$, $p < .001$ two-tailed). Perhaps more interestingly, a Sign Test comparison between this condition and average performance on the immediate recall controls reveals that they are not significantly different from one another (17+, 21 -, and two ties, ($N=38$) $Z = .487$, $p > .05$, two-tailed). Close scrutiny of the relevant serial position functions in Figure 3:1 shows that the reduced recency portion expected because of the delay in the repeated-identical condition, is compensated for by an improvement in the pre-recency portion when compared with controls.

3:3:3 Summary of Experiment 3

The results of Experiment 3 are therefore quite provocative. A detailed discussion will be postponed until Experiment 4 has been presented. In the meantime the main findings of the present experiment can be summarised as follows :

(i) When recall is delayed by an interpolated task, distractor material of the same class as the memory string will have a more harmful effect than more neutral material of a different class, and this effect seems fairly uniform across the serial position function. This conclusion however requires to be modified in the light of results obtained in situations where the same items are involved in both memory and distractor lists.

(ii) Thus presenting the same items in both memory and delay lists, but where the order of the items differs, will ~~ameliorate~~ ^{may even} the deleterious effect of class similarity, and produce performance comparable to delay conditions where the interpolated material is of a different class.

(iii) When the two lists (memory and distractor) contain the same items and in exactly the same order, performance is elevated still further to approximate that of immediate recall controls. This effect seems to be the product of enhanced recall for early list items, while recency suffers the normal degradation due to delay (except for the very last item).

The effects of similar conditions will now be examined in a comparable experiment but where the distractor list is transposed to precede the memory string, in order to determine the direction of influence of these results.

3 : 4 EXPERIMENT 4 : EFFECTS OF VARYING THE CLASS OF DISTRACTOR
MATERIAL II : PRE-LIST 'DISTRACTOR'

3:4:1 Method

Stimulus Material and Procedure

With the exception of the control condition lists which were abandoned for this experiment, the stimulus material was exactly the same as that used in Experiment 3 i.e. the same basic 4 sets of lists were re-employed. The only difference was that the distractor lists were now placed immediately before each memory list instead of after them. As before all the material was pre-recorded on a Ferrograph recorder at a rate of one item per second with no break between distractor and memory sequences. Again each list was preceded by the signal 'ready' and followed by 20 seconds to allow time for recall. New instructions alerted the subjects to the requirements of the target detection task which was always spoken by the female voice, and always came first. Emphasis was again placed on the requirement only to memorise the consonant list spoken by the male voice. In virtually all other respects the procedure was the same as in Experiment 3. This time however subjects were permitted immediate recall of the list following presentation, after which they were to record their decision on the preceding detection task. As before response sheets were provided for these purposes.

Subjects

A further forty students from the Part I Psychology Course at the University of Stirling served as subjects and received a course credit for participating. They were assigned randomly to one of four equal groups, and were tested in groups of up to 10.

Scoring Methods

Once again, although both a lenient (absolute) scoring method and a strict order criterion technique were applied to the data, concentration will focus on the latter. However performance under both these procedures is depicted in Figure 3:2 where the lower panel refers to the present experiment, and the upper panel includes the comparable data from Experiment 3. From these data it is immediately obvious that memory performance in the present experiment, where the distractor precedes the critical string, is at an altogether higher level than under conditions of the conventional delay situation in Experiment 3.

Serial Position Analysis and the Effect of Similarity

The ordered scores computed as a function of input serial position for the current experiment are presented in Figure 3:3. The upper panel in this graph shows performance under standard consonant and digit pre-list conditions, and further reveals little difference between the two. This was confirmed by a Sign Test performed on each subject's total scores (pooled over serial position) for both conditions, which revealed 18 scores in the + direction, 19 in the - direction, and 3 tied scores. Further analysis seemed unnecessary to establish that the conditions did not differ significantly from each other.

The Effect of Identity

Scrutiny of the bottom panel of Figure 3:3 where the results of the two special cases of consonant pre-list are depicted, once again reveals advantages due to presenting the same items in both distractor and memory list. Again also, these benefits seem to be confined to early list positions, and this is especially true for the repeat-identical condition. The advantages apparently accruing to these conditions were confirmed by the following tests. When the repeat-identical condition scores for each subject were compared with the average list score under the standard consonant pre-list, a Wilcoxon Matched Pairs Test (large sample) revealed a significant difference ($T=169$, $(N=39)$, $z=-3.08$, $p < .01$ two-tailed). With respect to the repeat-random condition however, scrutiny of Figure 3:2 bottom panel reveals that there are unlikely to be any differences between this condition and either the standard consonant or digit pre-lists when measured by the strict-order criterion. All the relevant data points appear to coincide. However the more obvious difference between the repeat-random and repeat-identical conditions by

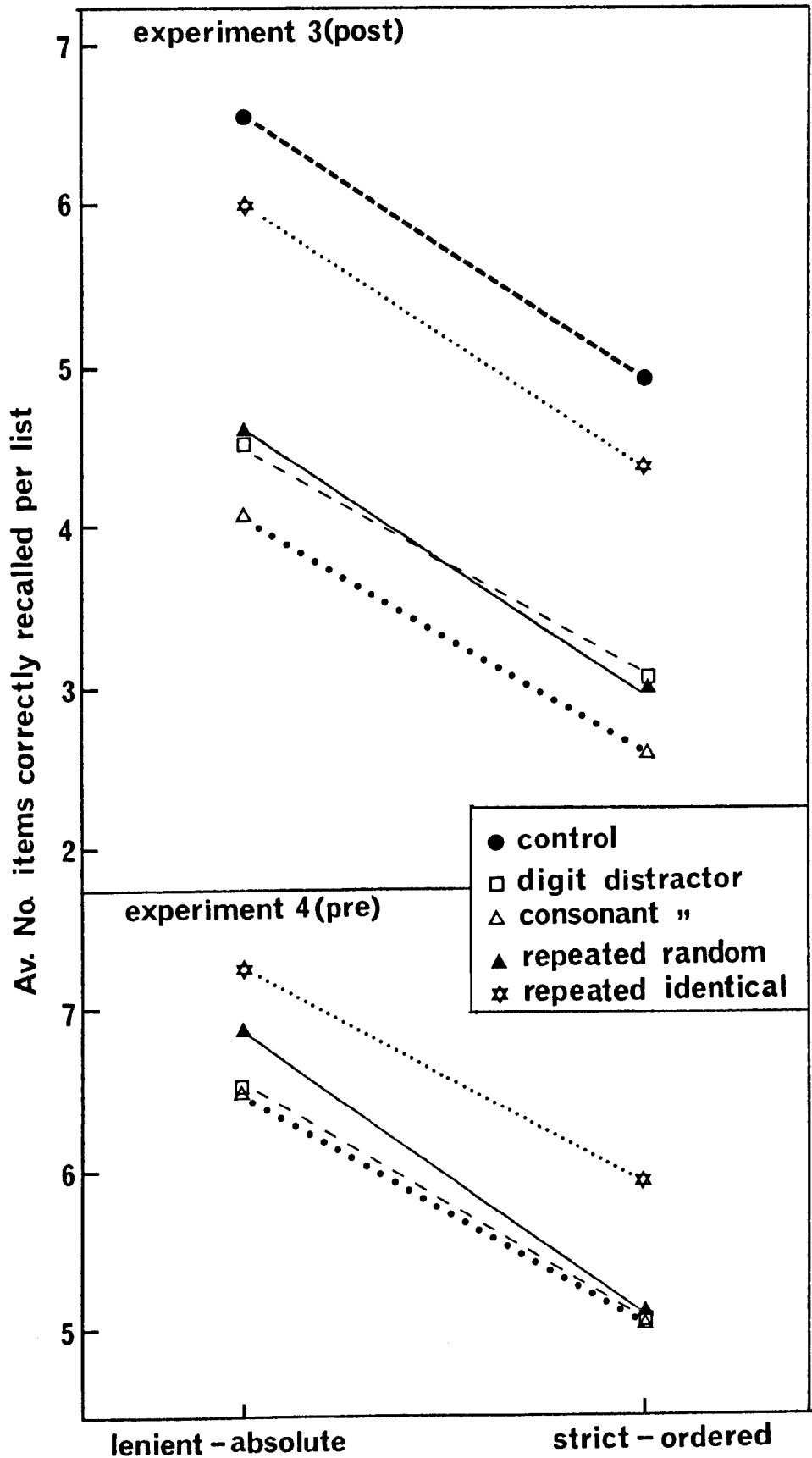


Figure 3:2 Average number of items correctly recalled per list under all distractor conditions as a function of lenient and strict-ordered scoring. Upper panel - post list conditions of Experiment 3; lower panel - pre-list conditions of Experiment 4.

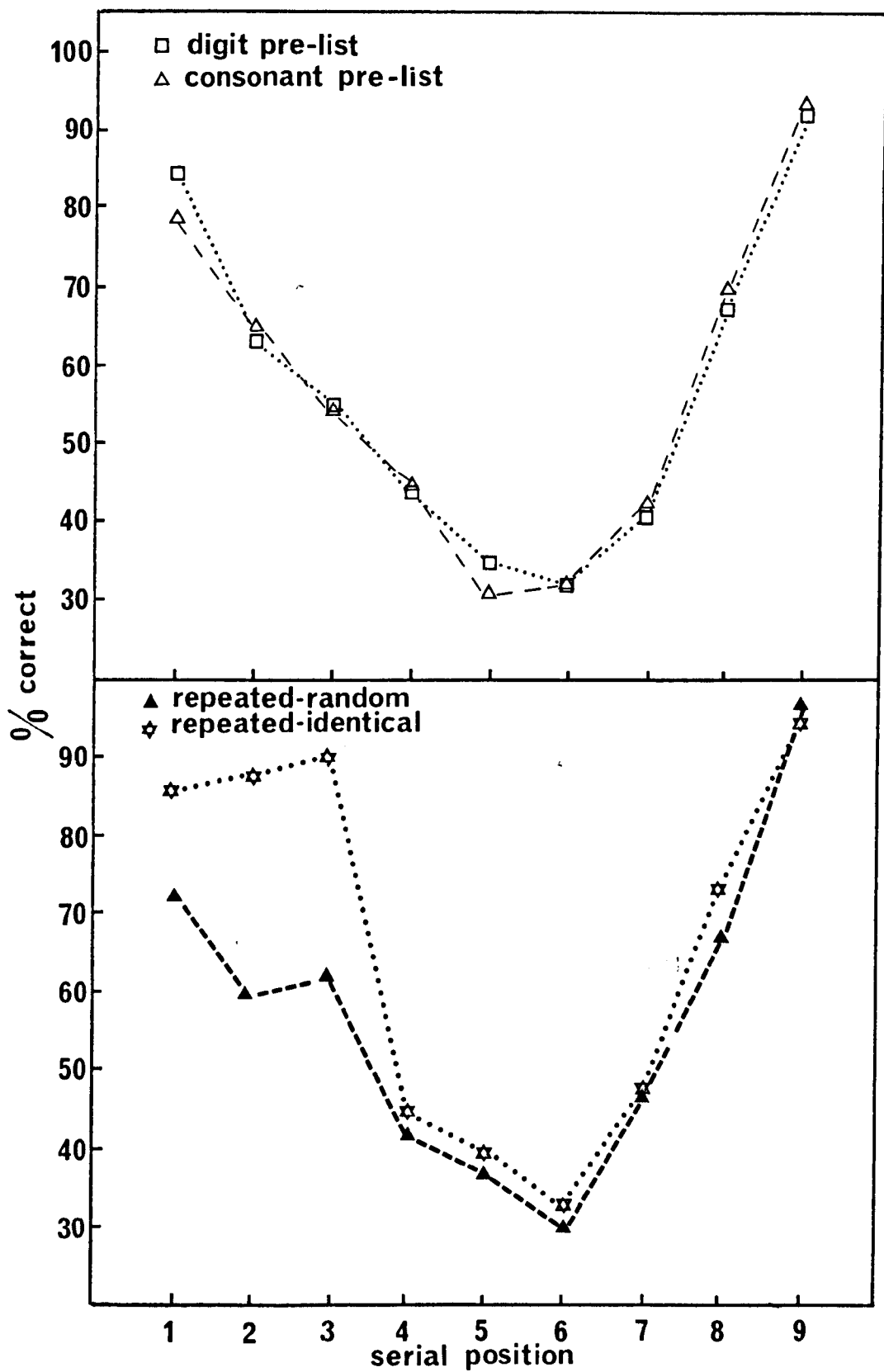


Figure 3:3 Serial position functions for all pre-list distractor conditions

the same scoring procedure did seem worthy of further testing. Indeed a Wilcoxon revealed them to be statistically separable ($T=135$, ($N=31$), $Z=-2.214$, $p < .05$ two-tailed). The slightly lower significance level on this comparison, when considering the apparently large difference on the graph (Figure 3:2) seems likely to be due to the fact that only one list per subject is now being compared, and therefore variability is likely to be somewhat higher. Figure 3:2 also reveals that the repeated-random condition, when measured by the lenient criterion, appears to show improvements relative to the standard digit and consonant pre-lists. Indeed a comparison of the 'absolute' scores for the repeated-random condition and the relevant average scores for the consonant pre-list revealed this difference to be significant (Wilcoxon $T=234$, ($N=39$), $Z=-2.18$, $p < .05$ two-tailed.) Furthermore when the repeated-random and repeated-identical conditions are compared without regard to order, they now appear statistically inseparable (Wilcoxon $T=112$, ($N=24$), $Z= -1.085$, $p > .05$ two-tailed). A certain degree of caution however should temper this last conclusion, as Figure 3:2 still shows these conditions to be fairly well separated. Once again the higher variance involved in making comparisons on the basis of one list per subject might have contributed to this result. It should be recalled however that the very special nature of the conditions being examined, and the prerequisite that subjects are unaware of such manipulations demands that only one example of each of these conditions is presented.

Finally, examination of the serial position analysis for these conditions shown in Figure 3:3 (bottom panel) clearly demonstrates that the major benefit of the repeat-identical condition list seems confined to pre-recency portions of the curve - and especially the first three items. As a note of caution however, it would appear inadvisable to place any emphasis on the somewhat atypical shape assumed by the primacy portion of this condition (ie. the slight upward trend over the first 3 items). Other pilot work with this paradigm (not reported here) also displayed primacy enhancement for identical pre-lists, but showed the effect conforming to a more conventional appearance.

3:4:3 Summary of Experiment 4

Despite the inherent dangers of variability which are likely to accompany conditions where performance on only one list is being tested, the effects in the data from this experiment (as with Experiment 3) seem remarkably robust. When submitted to statistical analyses, the observations based on the graphed data seem to be borne out without producing inconsistencies. The principal conclusions which can be drawn from Experiment 4 can be stated as follows :

(i) When a 'distractor' in which the material only requires to be monitored as far as a classification decision precedes a memory list it seems to make little difference whether the distractor material is of the same, or a different class, to that of the memory string. That is to say recall performance is independent of class similarity in this situation, at least for the conditions tested.

(ii) When the pre-list distractor material contains the same items as the memory string, but where order of presentation is not the same in both lists, recall performance as measured by a strict-order criterion, is unlikely to differ from other distractor conditions which contain the same, or even different classes of material. However when a lenient scoring criterion is employed, this repeated-random condition produces recall which is superior to these other conditions noted.

(iii) When a preceding distractor list is identical to a following memory list in both items and order of presentation, then recall of the memory list is substantially elevated beyond all other distractor conditions. This effect is particularly dramatic over the primacy region of the serial position function.

3:5:1 Preliminary Remarks

Before passing on to the theoretical implications of these results just presented, it is appropriate at this point to make certain preliminary observations concerning particular features in the data described above.

In the first place it should be noted that the control condition (immediate recall) included in Experiment 3, while approximating the typical free recall function, does not completely correspond to the latter, especially with regard to the recency portion. As mentioned previously, at least two reasons can be advanced for the slightly lower recall obtained in the present setting. Firstly subjects were actually involved in an 'ordered-free recall' task, and this additional imposition may have reduced performance accordingly. Secondly there was no guarantee that subjects output terminal items first, and this is typically important in establishing a high recency effect (Tulving and Arbuckle 1966). Furthermore, the configuration of the response sheets (where each list was represented by a horizontal series of adjoining boxes) meant that no post-experimental check could be made on this aspect of recall procedure.

Next it is clear that the delay conditions imposed in Experiment 3, while reducing recency, do not completely eliminate the effect totally. Such a result is not restricted to the present investigation however. For example, Glanzer, Koppenaal, and Nelson (1972) using a free recall paradigm and a very short delay list comprising four words obtained essentially similar findings. The most likely explanation of these effects, as suggested during the introduction to this Chapter, is that they represent the product of a situation where the distractor does not fully occupy the subject's attention, by being either so brief (cf Glanzer et al 1972) or fairly easy (Experiment 3). This argument is reinforced in the present investigation when one considers the fact that 'detection' performance on the distractor target items was virtually 100%. Under such circumstances one can assume that little difficulty has been encountered, and therefore a certain amount of spare processing capacity may have been available for continued attention to the memory items - especially those terminal items for which there was so little time during presentation.

It is interesting to note in passing that these remarks highlight an apparent paradox with regard to the evaluation of subsidiary task studies (whether these tasks are presented concurrently with the memory items eg Silverstein and Glanzer 1971; Baddeley and Hitch 1974; or subsequently as a delay list, as in the present Experiment 3).

Thus if the distractor task is assumed to have been easy because performance on it has been close to 100%, it cannot therefore be assumed that some additional processing of the memory items has not taken place. This in turn implies that a suitable level of difficulty in the distractor task can only be judged by the presence of errors on that task. However the appearance of errors in distractor task performance could also be interpreted as indicating that subjects were still paying 'illegal' attention to the memory items, and not devoting all their efforts to the current stimuli. Resolution of this problem however seems fairly clear. Where careful consideration of the effects of distractor activity is demanded, then the distractor should be tested first in isolation until a firm baseline performance is established which is below possible ceiling effects. This can then be compared against the conditions where memory and distractor activities are coupled together. Any significant lowering of the distractor task performance in this latter situation would then raise suspicions that the memory list was receiving unauthorised attention. That this is not standard practice in most memory experiments employing distractor designs is somewhat surprising. However it has to be admitted that the present Experiments are as guilty of this omission as others which could be cited.

These comments notwithstanding, the important features in the data from Experiments 3 and 4 are apparent in the comparisons between the type and nature of the material employed in the distractor lists. Therefore it is to these that attention will now be turned.

3:5:2 The Nature of the Effects of Varying Distractor Material

(i) Post-list Delay Tasks: Clearly the presentation of any material which requires to be attended to immediately following presentation of a memory list, lowers recall of the latter. This finding is in total agreement with innumerable reports in the literature, as is the fact that it is recall of terminal items which appears to suffer most under such circumstances (cf Glanzer 1972).

In addition the present results demonstrate that even the relatively undemanding task of monitoring a stream of alpha-numeric stimuli to determine their class, and where no further analysis of the items is required, is sufficient to produce this deleterious effect upon memory performance.

Furthermore when the class of item contained in both distractor and memory list is the same, a further degradation in recall performance is observed. This could occur for two reasons, which are not mutually exclusive. Firstly it could be the result of a time-sharing operation which seeks to continue 'illegally' to process the memory items while simultaneously monitoring the distractor list. Under such circumstances, difficulty is likely to be encountered in keeping appropriate, and separate track, of the two sets of material. On the other hand the result could occur through retrieval difficulties at the time of recall where the now 'older' relevant memory items have to be accessed through a barrier of 'newer' but irrelevant similar material. Thus far the results are not fundamentally different from many existing findings. One exception however is that the data observed in Experiment 3 (Figure 3:1 upper panel) imply that the effect is fairly uniform across all serial positions. This is strongly suggestive that the effects of class similarity need not be restricted to pre-recency portions, but can be evidenced across terminal items as well (cf Glanzer, Koppenaal and Nelson 1972).

Another and perhaps more major point of departure concerns the fact that these detrimental effects of class similarity can be removed by the use of the same items in both memory and distractor tasks. Thus the repeated-random condition raises performance to a level equivalent to that obtained with distractors containing a different class of material, while the repeated-identical condition elevated performance to a level equal to that of immediate recall controls. This latter result seemed entirely due to vastly superior recall of early portions of the list, with a normal recency impairment under delay conditions still in evidence. (This last comment requires to be modified in the light of the elevated recall of the very last item apparent in Figure 3:1). Clearly these results suggest that recall of the memory list is incremented by some amount due to the re-presentation of the same items, and that this is somehow more effective and substantial for early items in the memory list, and where order information is preserved.

(ii) Pre-list 'Distractor Tasks': The situation with regard to preceding distractors is arguably more intriguing. Firstly, there is no basic difference in memory performance as a function of class similarity between the two lists: witness the identical performance under both digit and consonant pre-lists. Thus effects of class similarity in this context are uni-directional. This is perhaps hardly surprising, given that the distractor material did not have to be memorised, but merely classified. Under such a scheme there is little reason to suppose that

sufficient processing was devoted to the irrelevant items for them to constitute a noisy background against which the learning of the memory material has to be conducted - even when the semantic class of both sets of material was the same. However that traces from the distractor list survive in some form is evident from the beneficial effects they can produce when they represent the same items as those contained in the ensuing memory list. That is to say that apparently they need not be sufficiently strong to interfere, but can nevertheless be made available to improve given the appropriate conditions. This finding is reminiscent of the data presented by Hebb (1961) but it is necessary to note that his repeated lists were all to be memorised. The present situation is more dramatic in suggesting a similar finding where one of the lists does not require to be learned. Once again in this context the most dramatic feature of the results is evidenced under the repeat-identical condition list, and the facilitation effect is much more substantial over the primacy region. This in turn suggests that the initial items in the distractor task somehow survive the intervening events better, and in a form which can be capitalised upon when the memory list begins.

3:5:3 Theoretical Implications

As will be encountered in other sections throughout this investigation, aspects of the results appear to offer some comfort to various theoretical positions in turn, but when taken as a whole, are not supportive of any one model.

(i) The Modal Model: None of the results from the delay task situation (Experiment 3) is beyond explanation in terms of the modal model (Waugh and Norman 1965; Atkinson and Shiffrin 1968; Glanzer 1972). Thus the removal of recency by interpolated activity, and the basic interfering effects of class similarity would be predicted by the theory. The only slight discrepancy in this picture would appear to be that the class similarity effect in the present experiments not only occurs over the secondary memory component (which is assumed to reflect semantic relationships) but also across those recency items deemed to reflect the short-term store. However the theory might still wish to claim that this latter finding also reflects contributions from the long-term component, as witnessed by the survival of these items after intervening delay which may have resulted from continued and 'illegal' processing of the memory stimuli following presentation.

Likewise the repeated list conditions in Experiment 3 testify to the value of additional rehearsal activity (cf Rundus 1971). That is to say that the memory items benefit from being 're-presented' during the delay list and this serves as extra processing. Furthermore in the case of the identical distractor, this list is likely to be recognised as being the same, and such recognition is more likely to be the case for initial items (which are being compared to the strongly-acquired traces of primacy from the memory list).

Problems for this class of model however are encountered with handling particular results from the pre-list distractor conditions (Experiment 4). This is particularly the case with the enhanced primacy as a result of repeating the same sequence. Despite the fact that one feature of the Atkinson and Shiffrin (1968) model is that transfer between the short- and long-term stores occurs inevitably as a structural feature of the system, it is not at all clear that this can be extended to cover the effect just described. For example, the short-term store processing the items in the distractor list is required to grant exclusive privileged status to the first three items if the present results are to be believed. Certainly no store operating on a serial displacement principle could account for this effect without appealing to differential rehearsal of these primacy stimuli - something which can be ruled out in the context of the present experimental conditions. And even a store which operates according to a 'random bump-out' displacement principle (which might favour initial items as being longest resident) would find it difficult to explain the vastly superior and almost equal performance on the first three items only; quite simply the effect seems too selective to be explained by mechanisms of the kind just described. Thus on one level the Atkinson and Shiffrin (1968) type of model could handle the finding of enhanced primacy by claiming that the initial portion of the memory list receives an extra boost from the survival of the traces from the equivalent part of the distractor list. On the other hand the model cannot easily account for the durability of these traces in the first place. The model, and other versions within this class, must therefore be regarded as inadequate in this respect and suitable explanation must be sought elsewhere.

(ii) Levels of Processing: The situation with regard to the other major theory is even less satisfactory. Beginning with the delay conditions in Experiment 3 it is clear that the levels account (Craik and Lockhart 1972) would predict the removal of recency in much the same way as it handles delayed free recall experiments. However the situation with respect to the class similarity effects is not so straightforward.

One deduction from the theory might be that in order to explain the deleterious effect of class similarity, it would have to be assumed that both sets of material (memory and delay lists) were processed to the same semantic depth before any competition might result. (Although the theory does not actually contain explicit statements on retrieval this could be one interpretation). This however seems hardly likely to be the case given that subjects were required to memorise one list and merely monitor the other. Thus while the classification task could be said to have involved semantic processing (and as pointed out in the introduction to this Chapter, the theory does not even permit this statement to be made unequivocally or with confidence) it is not likely to have received the same degree of elaborate encoding. This last statement now echoes the position developed by Craik and Tulving (1975) but now it implies that the distractor material should not have been processed to the extent that it is capable of producing any interference with the memory material. Without more explicit detail, particularly with respect to possible retrieval difficulties, the theory does not seem capable of accounting for such data. The theory can however account for the beneficial effects of an identical post-list distractor, and does so in much the same way described for the modal model.

A further lack of specificity is encountered in dealing with the beneficial effects of the pre-list conditions. On the one hand the model does predict that the classification task will lay down some form of trace (whether this is semantic processing or not). This follows from the theory's assumption that any form of processing activity devoted to a stimulus will render that stimulus as durable as the depth or degree of encoding performed upon it. Moreover the premise appears to be supported by incidental learning task studies. The problem however lies in determining whether the classification task is semantic or not (as this will determine the durability of the traces), and under what conditions it would be likely to affect recall of the memory string. This exercise - already tortuous - is further confounded by the specific locus of the effect. As noted previously, a levels account seeks to explain primacy by appealing to Type II or more elaborate encoding. In the case of the distractor task used in the present experiments this seems totally implausible.

Difficulties of both prediction and explanation therefore appear to plague this theoretical framework in its present state.

(iii) Alternative Accounts. (a) Recency Considerations: It is probably true to say that the conditions operating in the present experiments do not address all the specific theories of recency encountered in Chapter 1 in as direct a way as do other experiments during the course of this investigation. For example, both the Bjork and Whitten (1974) account and the Baddeley and Hitch (1977) model would assume that under conditions of delayed recall (Experiment 3) terminal items within a list no longer form the basis for recency retrieval (unless the items themselves are separated by similar interpolated activity thus reconstituting an ordered series). Further the Bjork and Whitten (1974) model seems inappropriate for application to the immediate recall of lists (Experiment 4) because cumulative rehearsal of the series is likely to have been involved and the account does not handle such situations.

The exception to this however is that the data do provide a test of the Craik and Jacoby (1975) triple-theory of recency determination. This is in respect of the class similarity effect. These authors note that recent items can be retrieved from a form of primary memory (process 1). When attention is diverted from the contents of this mechanism, a certain amount of information is lost, but total forgetting does not occur; The events are still capable of being recovered from recent episodic memory (by the two remaining processes of 'backward-scanning' and 'guided reconstruction'). However it is further claimed that an interpolated task which involves similar events to the memory items will reduce the efficiency of these retrieval mechanisms- either by reducing the discriminability of the items in the case of the backward-scanning operation, or by interfering with guided reconstruction since similar features are now shared by a number of recent events some of which are relevant to recall, and some of which are not. Such a view would undoubtedly predict the deleterious effect of following a consonant memory list with a consonant distractor, and further would also require that this effect was evident over the recency portion of the curve. This is precisely what the data of Experiment 3 suggests, and on this occasion therefore this particular model is supported.

None of these models however - by definition - is applicable to primacy effects.

(iii) (b) Primacy Considerations: Thus far it has been argued that the benefits to primacy which result from the memory list being followed by an identical distractor list can just be handled by the two major theories. This assumption rests on the fact that the memory list has

already been 'learned', and that acquisition of the early items has therefore been strong. Thus upon the arrival of the distractor list, a process of 'recognition of identity' can take place for these items. This in turn serves to further encode the initial items. Although some benefits may also accrue to other list items the effect on primacy seems likely to be the greatest. Such an explanation is not so plausible when the paradigm is 'reversed' however and the material to be monitored precedes the critical memory set. Yet under such circumstances primacy of the memory list is still facilitated, and the size of the effect is still substantial.

At this point it seems necessary to appeal to some form of positional distinctiveness (eg Murdock 1960) which can render initial items in a series somehow more memorable. As this finding was not strongly predicted however a degree of post hoc explanation seems inevitable. It will be recalled that one hypothesis apparently offered by this model was that when a memory list is preceded by items drawn from the same class, then a loss of primacy might be expected. This would come about because the salience of the initial portion of the memory list has been to some degree reduced. The evidence of Experiment 4 clearly indicates that this is not the case and it must therefore be assumed that the encoding operations performed on the critical memory stimuli are sufficiently powerful to overcome any such effect. However the survival of the traces of the primacy region of the identical pre-list which is assumed to underlie the enhanced memory performance offer some support to the theory, as no alternative theoretical account seems adequate.

At this point it is instructive to note that there are examples of similar effects in the literature which appear to support such a notion. In this context, the finding of primacy effects in certain incidental learning tasks (eg Baddeley and Hitch 1977) is particularly suggestive of a 'special status' for primacy. Indeed tentative models of the process which might underlie such an effect have been offered (eg Hockey and Hamilton 1975; Hamilton, Hockey and Rejman 1977). Such accounts assume that a state of 'preparedness to receive' a set of stimuli can exist within the organism which in turn result in a special storage status being afforded initial items. This undoubtedly places the mechanism at the perceptual and physiological level, and as such beyond the reaches of a test involving the present data. Thus while the primacy encountered in tasks such as incidental learning situations could be viewed as the product of a retrieval strategy which utilises distinctive cues within a well-ordered series, there may yet be other examples of primacy effects which require to explain why items survive

in this form, and these might require explanations couched in terms of more fundamental processes.

At this stage, and on the basis of the current investigations discrimination between these options is not possible. For the moment it must be concluded that there is evidence of primacy survival, which is not readily explained in the more conventional terms of differential rehearsal (cf Bruce and Papay 1970).

Two experiments were reported which examined the effects of both post-list and pre-list distractor tasks in which material only had to be classified but not recalled, upon the recall performance of a critical memory list. In this context the particular effects of 'class similarity' and 'list identity' between the two halves of the task were explored. On the basis of the results presented the following broad conclusions can be drawn.

(i) Where distractor and memory lists contain items drawn from the same conceptual category, deleterious effects will be encountered when the memory list is followed by the distractor, but not when the distractor precedes. The degradation in recall performance experienced in the delay conditions is likely to be uniform across all serial positions.

(ii) Where both distractor and memory lists contain exactly the same items, recall performance will be enhanced whichever way round the tasks are presented. The benefits derived under these circumstances are particularly noticeable where order information is preserved across both lists, and appear to be much more specific to the primacy region of the recall function.

(iii) All the models examined for theoretical explanation of these effects had a variety of successes and failures. Of the general models, perhaps the least satisfactory was the levels of processing account where difficulties with the definition of particular encoding operations, and a certain lack of specific detail, made prediction difficult. The modal model was supported by much of the data from the delay condition experiments, but was less satisfactory in accounting for the pre-list results. In particular the apparent survival of early items from the preceding identical distractor were especially difficult for this class of model. As no other generally agreed account seemed an adequate explanation of this effect an appeal to some modified version of the positional distinctiveness hypothesis seemed justified. The precise mechanism responsible however would appear to await further data.

CHAPTER 4

FREE RECALL OF CATEGORISED MATERIAL

IN BLOCKED AND RANDOM PRESENTATION FORMAT

- 4 : 1 PREFACE
- 4 : 2 GENERAL INTRODUCTION
- 4 : 3 EXPERIMENT 5: FREE RECALL OF BLOCKED-CATEGORY LISTS -
IMMEDIATE RECALL
- 4 : 4 EXPERIMENT 6: FREE RECALL OF BLOCKED-CATEGORY LISTS -
DELAYED RECALL
- 4 : 5 GENERAL DISCUSSION OF EXPERIMENTS 5 AND 6
- 4 : 6 SUMMARY OF EXPERIMENTS 5 AND 6
- 4 : 7 INTRODUCTION TO EXPERIMENTS 7 AND 8
- 4 : 8 EXPERIMENT 7: FREE RECALL OF BLOCKED-CATEGORY LISTS
LONG LISTS I
- 4 : 9 EXPERIMENT 8: FREE RECALL OF BLOCKED-CATEGORY LISTS
LONG LISTS II
- 4 : 10 GENERAL DISCUSSION OF EXPERIMENTS 7 AND 8
- 4 : 11 SUMMARY OF EXPERIMENTS 7 AND 8
- 4 : 12 GENERAL SUMMARY OF CHAPTER 4

Repeated reference has been made to the free recall paradigm as a major source of evidence for much current theorising without the technique actually being employed in its pure form in this research. Up until now this has been appropriate. For example the case advanced in Chapter 2 challenging certain fundamental assumptions regarding short-term memory mechanisms and how they may be reflected in FR recency required a different ('purer') experimental format in order to be tested. However certain features of the thesis being proposed can only be evaluated adequately in the context of the free recall task itself. It is to that paradigm therefore that attention will now be turned. In particular experiments using semantic material are described. Under conditions where such related material is presented in blocks within free recall lists, atypical recall profiles are found exhibiting within-list primacy effects. These are used in a critical examination of free recall processing. A second set of experiments extends the length of such lists and succeeds in obtaining a recency effect spanning the groups of related items, in addition to normal terminal item recency. The theoretical implications of these results are discussed.

4:2:1 Processing in Free Recall

Previously it was argued that in the absence of any special instructions, subjects tend to process fixed length memory lists in a particular and predictable manner (Rundus 1971). Leaving aside questions of retrieval, under this scheme the typical free recall function is seen as being determined primarily by an extremely enduring and replicable strategy. Initially, subjects' attentions are devoted to rehearsing early list items. Subsequently these items - now fairly strongly encoded - become anchor points to which later items are attached as presentation proceeds through the list. This in turn serves to strengthen the early items still further while simultaneously ensuring that progressively less processing is afforded terminal items. Thus the rehearsal groupings measured by Rundus' (1971) technique show evidence of a bias towards the recirculation of early list material. Not only does this correlate remarkably well with the ultimate levels of recall achieved using final free recall procedures (Craik 1970; Craik, Gardiner and Watkins 1970) but the account fits in well with the known effects of presentation rate (Murdock 1962; Glanzer and Cunitz 1966). Because of this bias, any additional time available to the rehearsal mechanism during slow rates of presentation is much more likely to be devoted to further processing the early list items. Attention to terminal items on the other hand will remain at a fairly low near-constant level for each input position.

The crucial question however revolves around whether this processing behaviour is as immutable as it appears (or whether it is merely the normal conditions of the paradigm which produce it). Certainly the explanation outlined above would appear to include a degree of voluntary control over the operations performed during acquisition. There is then a suggestion, albeit implicit, that there may be conditions under which the apparently preferred processing style could be altered. In addition, experiments by Craik and Watkins (1973, Experiment 2) and Shallice (1975) suggest that such changes can be induced by instruction. If therefore it could be demonstrated that the usual encoding pattern could be disrupted by means other than deliberate instruction (i.e. if it were to emerge as a natural consequence of subjective strategy due to some other variable) then several purposes would be served.

(i) Firstly, this would appear to have implications for the phenomena of primacy and recency which are the focus of attention for this investigation. This in turn would have a bearing upon the theoretical interpretations

of these effects.

(ii) Secondly, there is the general comment that any dramatic change in the free recall function would tend to reinforce the argument that subjects are capable of considerable flexibility in deploying their encoding resources. More specifically it would provide an opportunity of identifying and clarifying some of the conditions surrounding the operation of the control processes which are a feature of certain models (e.g. Atkinson and Shiffrin 1968) but about whose characteristics relatively little detail is known.

Evidence which appears to favour an explanation of free recall in terms of an encoding strategy which subjects very quickly select as optimal for the task in hand comes from a number of sources. For example such an assumption is central to the argument of Craik and Lockhart (1972), although it should be noted that their theory rests on considerations of the type of processing rather than the sheer number of times an item is rehearsed as in the Rundus (1971) account. Further support for the voluntary nature of the processing strategy comes from Watkins and Watkins (1974). In a study where the length of the memory lists varied it was shown that only when the end of the list could be accurately anticipated did subjects' recall exhibit the typical FR function. Finally to be included within this category of evidence are those studies which demonstrate pronounced within-list effects contingent upon alterations in the stimulus material or slight variations in the temporal sequence of the lists. The importance of these results in demonstrating such a radical departure from the traditional bow-shaped curve merits more detailed consideration.

4:2:2 Within-List Effects

(i) Changes in the temporal structure of the list. Experiments have already been described in which the temporal grouping of the list items was shown to affect the serial position curve (eg Ryan 1969; Gianutsos 1972). Typically the procedure entails inserting pauses after every so many items, while overall list presentation time is equated with control lists where no such pauses occur. The effects of such manipulations were generally twofold. Firstly the overall level of recall was raised relative to control lists, although there is the suggestion that this may only be true for the short-term component (Gianutsos 1972). Secondly the shape of the recall function was altered to produce within-list effects directly related to the grouped items. It is probably imprudent to draw any firm conclusions regarding the shape of these within-list functions as the majority of experiments employed groups of three items - the bare conditions for a beginning, a middle and an end. Nevertheless there is the suggestion that the group

functions resemble the usual list function exhibiting both primacy and recency, and this is borne out on the few occasions where larger groups are employed (eg Ryan 1969, experiment 2). These findings have tended to stress the importance of such factors as recall order (Gianutsos 1972) or a reduction in order errors as a function of grouping (Ryan 1969); indeed the latter's experiments employed an ordered rather than a free recall format. These comments notwithstanding, the best single interpretation of the results is one which appeals to induced changes in the allocation of processing during acquisition as a function of temporal grouping.

(ii) Changes in the list material: Further evidence of within-list effects comes from experiments where the nature of the stimulus material changes during presentation of the list. The best example of this comes from a recent study by Murdock and Carey (1972). These authors took as the starting point for their investigation the fact that a considerable number of studies have demonstrated that forgetting in short-term memory experiments can occur as a function of interference from both prior items (proactive interference or PI) and from subsequent items (retroactive interference or RI). For example, effects attributable to PI and RI respectively have been found using a variety of stimulus materials viz. consonant trigrams (Underwood and Schultz 1962), whole lists (Craik and Birtwistle 1971; McGeoch and McDonald 1931), and sentences (Slamecka 1960; 1961). Moreover Wickens (1970) has shown that it is possible to achieve 'release' from the effects of PI by changing the nature of the stimuli after several trials, thereby returning recall performance on that trial to virtually the original level. It should be noted in passing that no such comparable release from the effects of RI has been demonstrated - a point which does not seem to be emphasised by the authors.

Given this background, Murdock and Carey (1972) argued that such effects ought to be present within each list in single-trial free recall. After all, each item in a list with the exception of the first and last, is preceded and followed by other items. In order to demonstrate this modality of presentation was selected as the dimension along which items would vary during the input sequence. Potential 'release' conditions, according to this argument, are created every time the modality changes. Using 20-item lists three basic constructions were presented to the subjects: (i) where all 20 items were presented via the same modality, either visual or auditory, (ii) where the first 10 items were presented in one modality and the second 10 in the other, and (iii) where modality was switched after blocks of 5 items.

There were two main findings to emerge from this study which are of particular relevance to the present discussion. Firstly, the greater the

number of 'blocks' in the input list (caused by switching presentation modality), the higher was the ultimate overall level of recall. Secondly, when recall was plotted as a function of input serial position, there was evidence of a 'scalloped' shape for each of the modality blocks. When this occurred it was qualitatively similar to the function normally obtained for whole lists i.e. exhibiting both primacy and recency components. Murdock and Carey (1972) took this as support for the 'release' hypothesis and further went on to claim that a similar result should obtain for lists containing blocks of items drawn from different semantic categories. Indeed one could argue that the effects of such a manipulation would be even more dramatic, for Wickens (1970) has shown that changing the taxonomic class of the stimulus material is one of the most potent determinants of release effects in the Peterson paradigm.

Two brief and related comments can be made which cast some doubt on the Murdock and Carey explanation however. Firstly, the interpretation of within-list recency effects as being attributable to release from RI seems questionable in view of the lack of any other corroborative evidence. The author is unaware of any study within the extensive literature on interference theory which replicates a release from the effects of RI. Secondly, inspection of the data reveals that when such within-list recency effects were obtained they were present only for blocks of auditory items. In the absence of a direct test, this could be taken as strong suggestive evidence of the effect being modality specific. Indeed such an explanation would tend to be supported by a large body of other evidence which shows an advantage for auditory presentation across a wide variety of tasks (see Tulving and Madigan 1970; Penney 1975, for comprehensive reviews of this research).

These criticisms of the explanation of the results notwithstanding, Murdock and Carey's (1972) 'blocked' paradigm, and the within-list serial position effects it produces, seems to offer a potential experimental vehicle for exploring changes in the processing and retrieval operations performed in otherwise standard free recall. Taken together with the prediction concerning semantically-related material this provides opportunities for evaluating some of the main theoretical positions of interest to this discussion. Of particular interest in this context will be further discussion of the data of Rundus (1971) to appear in a later section, which indicates that the inclusion of related items produces very definite and predictable changes in the acquisition strategy of the subjects.

4:2:3 Semantically Related Material

(i) General Remarks: To date experiments conducted by the author have employed very simple stimulus material (eg letters and digits). This has been quite deliberate and there are obvious reasons which can be advanced in support of such a decision. Historically the tradition can be traced to the pioneer work of Ebbinghaus and his use of nonsense syllables. Such material clearly minimises the possible confounding effects of meaning and thus permits a relatively uncontaminated view of memory processes. Moreover it can be shown that experiments with very basic materials are capable of providing insights into fairly complicated types of encoding operations; Miller's (1956) evidence of the recoding of strings of binary digits would be one such classic example. Despite this it can be argued that the use of such material still imposes certain limitations on the kinds of processing which can be employed in short-term memory tasks. That is to say that the very simple nature of the stimuli may in some way be denying access to the study of more complex, semantic forms of encoding. This point was alluded to briefly in the last chapter during the discussion on whether 'levels of processing' approaches were capable of categorising a letter/digit classification task as a form of semantic processing or not. The use of semantically-related material therefore would avoid such difficulties and perhaps permit even more direct tests of these theoretical positions which incorporate considerations of meaning and semantic encoding as fundamental concepts.

An extensive literature now exists on the recall of lists containing related items. This derives mainly from the work of Bousfield (1953) who demonstrated that the recall of lists containing words from several taxonomic categories was superior to the recall of lists containing unrelated items. Another result, important to the discussion is that recall is improved when the semantically related items are presented in blocked format rather than being randomly distributed throughout the list (eg Cofer, Bruce and Reicher 1966). However, one feature of this work is that typically the results are not subjected to serial position analysis; concern being directed solely at the ultimate levels of recall achieved under the various conditions. This omission is possibly not surprising as much of this work predates the recent extensive interest in the serial position function as a vehicle for exploring possible memory mechanisms. Clearly though, in the light of these recent developments, and in keeping with the general thrust of this investigation, a need to examine the serial position function pertaining to categorised lists has been identified.

One reason for conducting the experiments to be described in this section therefore was to provide such basic data for the blocked-category paradigm and in doing so to test the generality of the Murdock and Carey (1972) effects.

At this stage it is necessary to digress slightly to outline a few important findings from experiments in this area. These will be instructive when it comes to considering predictions concerning this experimental format which can be derived from the various theoretical positions under scrutiny.

(ii) Clustering During Retrieval: One basic problem which poses itself early on in this area is whether the higher levels of recall which result from providing semantically-related material are a result of input or output processes. Early views on this question tended to favour the latter interpretation. The evidence for this assertion is fairly straightforward. Examination of the subjects' recall patterns revealed that related items were output in clusters and that this occurred even when these items had been dispersed randomly throughout the list (Bousfield 1953). The conclusion that such findings place the locus of the facilitation at the retrieval stage received further support from studies which appeared to indicate 'response availability' as the crucial factor (eg Bousfield, Cohen and Whitmarsh 1958; Cohen 1966; Dale 1967). A similar point has been made by Tulving and Pearlstone (1966) who demonstrated convincingly the value of providing the category labels as cues during recall. Indeed they coined the phrase 'availability versus accessibility' to describe how material can be present in storage but is not necessarily retrievable without appropriate cueing.

There is then a body of evidence which appears to demonstrate that the main effects of presenting semantically-related items occur during retrieval operations. However there was no direct evidence of what was taking place during the acquisition phase, so this conclusion was always likely to be incomplete.

(iii) Clustering During Acquisition: The first piece of indirect evidence which can be cited to support the claim that some active organisation of material takes place during presentation comes from Tulving (1962). He noted that subjects in a multi-trial learning paradigm tended to recall groups items in the same order on successive trials - even when presentation order was varied from trial to trial. Tulving (1962) interpreted this as indicating that subjects were attempting to impose their own subjective organisation on the otherwise unstructured material. Fortunately, more direct evidence, which is of particular relevance to the present context, would appear to be provided by Rundus (1971). Once

again using the overt rehearsal technique to gain direct access to the processes taking place during intake of information Rundus (op.cit.) examined strategies during the presentation of 24-item lists which contained two six-item categories and 12 unrelated words. The results were clear cut; subjects' rehearsal protocols revealed that they were using information about the category membership of an item to guide acquisition strategy. Several related observations support this conclusion. Firstly, subjects appeared to structure the contents of each rehearsal set to match the item currently being presented, rather than merely including the new item in any ongoing rehearsal grouping. Thus presentation of a word from one of the categories not only increased the probability that other words from the same category would remain in rehearsal, but also triggered the return to active rehearsal of other words from the category which had been dropped previously. Finally, three quarters of the items within any rehearsal set were noted to be from the same class of material, and categorised words in general received more rehearsals than unrelated items.

From this evidence it seems clear that subjects engage in a process of active selection of the items to be rehearsed during presentation. Furthermore, in the case of lists containing related items this will result in these items being incorporated within the same rehearsal groupings i.e. a clustering effect during acquisition.

(iv) Organisation During Acquisition and Retrieval: Thus far the argument over whether the effects of presenting categorised lists can be attributed to the retrieval or the acquisition phase has been discussed as if these were mutually exclusive options. That this dichotomy is rather too simplistic is suggested by a number of studies which emphasise the interdependence of these two processes. For example, Tulving and Osler (1968) presented clear evidence of the storage-dependent nature of retrieval during the free recall of the 24 item lists. In this experiment the presence or absence of retrieval cues (weak associates of the to-be-remembered items) was combined factorially with their presence or absence during recall. The results demonstrated unequivocally that retrieval cues were only of value when they had occurred during both presentation and recall phases. A similar result is to be found in the Rundus experiment described earlier (Rundus 1971, experiment 4). Here the organisation which was observed during rehearsal activities was seen to be reflected in the subjects' recall. Thus within each category presented, the recall of items proceeded from the strongest to the weakest as measured by the number of rehearsals afforded each item. These experiments attest to the fact that the retrieval operations carried out by the subject are highly dependent upon the nature of the storage operations performed during acquisition.

Indeed it has even been shown that the form of organisation adopted by the subject, if inappropriate, can actually hinder learning under some conditions (Tulving 1966; Bower Lesgold and Tieman 1969).

The most common explanation of these findings is that subjects engage in their own organisation of the material during learning and that this process guides the retrieval operations subsequently employed during recall. If however, the conditions alter during the course of the experiment as in the investigations outlined above, this organisation may be rendered inappropriate (Tulving 1966) or continually disrupted (Bower, Lesgold and Tieman 1969) with the result that further learning is impaired.

4:2:4 Predictions from the Theories

The foregoing digression into the evidence on the recall of semantic material was necessitated by the proposed adoption of the blocked-category paradigm. As has been noted, this work has tended to remain within a framework of research which confines itself to investigating the principles of organisation, and to a large extent divorced from the debate surrounding issues such as the number and character of possible memory stores. However if the major models are to have any substantive validity then they must be capable of being generalised to encompass findings such as those noted in the preceding discussion. In the light of these results therefore, predictions concerning the effects of blocked-category presentation will now be derived from the models and approaches under consideration.

(i) The Modal Model: Once again for the purposes of this discussion attention will be confined to the contributions of the short- and long-term components and considerations of the peripheral sensory store will be ignored.

As previously noted, most of the models within this broad class which have been formulated in any detail include pathways to represent rehearsal (Waugh and Norman 1965), control processes (Atkinson and Shiffrin 1968), or both (Atkinson and Shiffrin 1968). That is to say that there is a degree of voluntary control which the subject can exercise over the selection of any item or set of items for rehearsal purposes. If one accepts as a starting point the evidence on processing presented in the last section, there is then a framework for predicting how these control processes would direct the flow of information under conditions of blocked-category presentation. This in turn leads to predictions from the modal model concerning which items are likely to achieve more durable status, and which items at the time of recall are likely to be resident in the short

term component.

When presentation of the first block begins items will enter primary memory or the short-term store where the earliest items will have the longest residence and therefore the highest probability of transfer to secondary or long-term memory. Evidence from the rehearsal studies (Rundus and Atkinson 1970; Rundus 1971) also indicates that these items are more frequently selected for further rehearsal, thus increasing their chances of transfer still further. Up until now the picture is virtually identical to the normal 2-store explanation of free recall primacy. However, upon the arrival of the second block of items, the process alters to take account of the new class of material being presented (Rundus 1971). In the terminology of the Atkinson and Shiffrin model, the rehearsal buffer is reset and reprogrammed, in this case being guided by the compelling internal organisation of the list. In this way processing continues with the beginning of each new category block marking a new starting point on which control and rehearsal operations converge. Under such a scheme a form of primacy would be anticipated for each category block as these items are more likely to have entered long-term storage. Recency on the other hand would only be present for the usual terminal list items as these would be the only items present within PM (Waugh and Norman 1965) or the rehearsal buffer (Atkinson and Shiffrin 1968) at the time of recall. The modal model therefore predicts that, under conditions of immediate recall, serial position curves obtained from blocked-category presentation should show signs of scalloping. This would, however, be confined to a primacy effect at the beginning of each block with recency only being present for the later items in the last block. This view contrasts with the findings and predictions of Murdock and Carey (1972) who found evidence of both primacy and recency at block boundaries.

Two-store models typically are less specific about their description of the long-term store than they are about the characteristics of the short-term component. For example, Atkinson and Shiffrin's (1968) formulation characterises loss of information from LTS as being due to decay, interference and loss of strength without specifying the relative weightings of these factors or under what conditions they operate. Their buffer model however, which was developed especially to handle short-term memory experiments, does state that retrieving an item from the long-term store is an increasing function of the number of times the item had been rehearsed and a decreasing function of the number of trials since the item has left the buffer. If one assumes that the initial items of each new block receive the same number of rehearsals as the initial items of any other new block, and that trials can be equated with intervening items, then this rule can lead to predictions concerning the relative recall levels of the various

items in LTS. In particular it would imply that the levels of primacy attained will be higher for later blocks than for earlier ones.

(ii) Levels of Processing: Turning to questions concerning the levels of processing approach (Craik and Lockhart 1972; Craik and Tulving 1975), the first observation one can make is that the blocked-category paradigm provides very clear opportunities for semantic encoding. After all, subjects are made aware of the list structure in advance; they are informed of the nature of the material within each group of related items (in the blocked condition); and they learn the lists in the certain knowledge that recall of the items will be tested. Given the evidence of the preceding sections, under such conditions it would surely be a perverse subject who failed to make use of the existing organisation of the material. This suggests that the Craik and Lockhart formulation would predict that advantages would accrue to subjects presented with categorised lists as opposed to those presented with lists of unrelated material - the original Bousfield (1953) result - as the former will undoubtedly encode the material at a semantic level, while in the latter case such relationships require to be established (cf Tulving 1962). However, the question which requires to be answered is whether the theory is capable of more precise prediction than this, especially regarding possible serial position effects.

For example, one possible interpretation of the levels approach might be stated as follows: Given that semantically-related material is used to construct the lists and where it can be assumed that the items are coded as far as their inter-item relationships, then a form of semantic processing has taken place. One derivation from the model might therefore imply that all such stimuli should be retained equally well. This in turn appears to predict flat serial position curves for all semantically-related items. It could be argued that this is an oversimplified extrapolation, and one which does not do justice to the approach. However it should be stated that it does represent one possible interpretation of the model as currently conceived, albeit an extreme one.

A view more charitable to the levels approach would involve consideration of the fact that the model seeks to explain any pre-recency effects in terms of changes in the semantic processing, while recency itself is assumed to be the product of shallow (phonemic) encoding. That is to say that just because semantically-related material is presented it does not mean that all the words are similarly encoded. Even this however would appear to involve problems for the model. The basic difficulty seems to stem from the fact that there has been very little attempt to examine potential differences within one basic processing level or 'domain'.

Beyond stating that information can be maintained (by the rehearsal) there has been no concerted effort to determine whether different kinds of semantic processing exist. One experiment made such an attempt (Craik and Tulving 1975, Experiment 1) but the results are of no direct relevance to the present context, and in any case the exercise was not extended. That this is a severe shortcoming is evident from the following argument. In the event of the blocked-category paradigm reproducing the within-list serial position effects obtained by Murdock and Carey (1972), it is not immediately clear how the levels approach could predict such findings. As an illustration, take the possible primacy effects which might occur at the beginning of each group of related items. One reading of the Craik and Lockhart (1972) position leads one to assume that such effects could not be explained on the basis of additional rehearsals afforded these items. This conclusion is merited by the fact that on the basis of other evidence (eg Jacoby and Bartz 1972; Craik and Watkins 1973) the advocates of the position do not consider the sheer number of rehearsals an item receives as a determinant of better retention. On the other hand one particular quote from the original paper appears to paint a slightly different picture: 'Several theoretical accounts of the primacy effect have been given, but perhaps the most plausible is that initial items receive more rehearsals and are, thus, better registered in LTS..... We agree with these conclusions.....' (Craik and Lockhart 1972, p.680). The authors then go on to claim that this is Type II processing. This is a trifle confusing. What Craik and Lockhart seem to be implying is that sheer amount of rehearsals will not lay down more durable traces under Type I processing but that this could be the case if Type II processing is being used. When this is taken together with other statements that maintenance rehearsal (Type I) could occur theoretically within any one level of processing, it seems fair to point out that the interrelationships of these various postulates are not explicitly worked out. This makes the prediction of when and where different kinds of processing are likely to be employed, extremely difficult. Furthermore, the picture does not seem any clearer if the notion of 'spread' or 'elaboration encoding' (Craik and Tulving 1975) is adopted. Why, for example, ought this to predict primacy effects for the blocked-category condition in the experiment to be reported? Would this suggest that initial items within each block are more elaborately encoded, because, for example, they are linked more effectively to the category superordinate? Surely subsequent items within the block are also coded as being part of the same taxonomic group. The model therefore again appears to be in difficulty because it

is required to address the possibility of differences within the domain of semantic processing, (the pre-recency portion), and as it stands, such a fine grain breakdown would appear to be beyond its scope.

In conclusion therefore, the levels of processing framework faces difficulties when precise prediction concerning complex serial position effects are attempted. Part of this difficulty stems from a lack of explicit detail in the account, while other problems are associated with an inability to handle possible differences within any one processing level - particularly the semantic domain. Similarly, because the theory neglects retrieval considerations for the post part, no clear predictions can be made for example with regard to how many categories would be likely to lead to optimal recall performance.

(iii) Alternative Accounts: Having dealt in some detail with the more general memory theories it is now necessary to consider the various other models which have been advanced to account exclusively for recency effects.

Of these the ordinal retrieval view of recency proposed by Baddeley (1976) and Baddeley and Hitch (1977) appears to suggest that no recency effects would be obtained with the proposed paradigm. This is because the inter-item relationships present in the list material are likely to offer an alternative, and more sophisticated retrieval strategy than the model's more primitive conceptualisation of recency. Under such a scheme retrieval is likely to be guided by the former and the mechanism sensitive to ordinal considerations will thus be overridden.

The Bjork and Whitten (1974) account on the other hand appears to exclude itself from consideration owing to the prerequisite restrictions placed upon the nature of rehearsals. In view of the evidence cited earlier on the processing patterns adopted for free recall, and in particular for lists containing related material, it must be assumed that a considerable amount of grouping rehearsal will take place. This in turn renders the Bjork and Whitten (1974) model inadmissible.

Of the remaining accounts, it can be argued that the positional distinctiveness formulation would predict both primacy and recency for the within-list blocks of related items. While it is true that such blocks do not represent complete dimensions (cf the conceptual position hypothesis), they do however represent mini-lists possessing a clearly-defined beginning and end. If therefore this is sufficient to create 'distinctiveness', then both primacy and recency should follow as a result.

The last model to be considered (Fraik and Jacoby 197) provides more than the possibility for recency. On the one hand any items still currently held within conscious awareness will be offloaded at the time of recall. This can be interpreted as predicting recency for terminal

list items. It does not seem likely that the model would predict recency for each group of related items in the blocked presentation format, but the third option - the reconstructive process - might suggest that later categories should be recalled better than earlier ones, although the lists would probably have to contain quite a few categories in order to test this prediction.

4 : 3 EXPERIMENT 5 : FREE RECALL OF BLOCKED-CATEGORY LISTS :
IMMEDIATE RECALL

4:3:1 Summary of the Rationale

To recapitulate, the starting point for the experiment to be reported was a study by Murdock and Carey (1972) which showed dramatic evidence of within-list effects in single-trial free recall when presentation modality was switched during input. It was decided therefore to conduct a similar experiment using groups of semantically-related items to create the divisions within each list.

At this point it should be noted that the use of categorised material affords one opportunity which was not available to Murdock and Carey (1972): Namely that of independently controlling the number of blocks and the number of categories within each list. For example, two types of list can be constructed. In the first, all the items from any one category are presented in one block, thus equating the number of blocks with the number of categories. In the second type, the selected members of a category are divided into more than one block, and these are then interleaved with other categories similarly subdivided. In this case the number of blocks, or switches, can be increased while the number of categories is held constant. This manipulation is important for the following reasons.

Firstly, the results of Murdock and Carey (1972) suggest that increasing the number of blocks per se increases the overall level of recall (as measured by total scores under the various conditions). In the present experiment however dividing the members of various categories into smaller sub-groups could be viewed as one step along a continuum towards randomisation; and this has been shown to produce inferior performance (Cofer, Bruce and Reicher 1966).

Secondly, of particular interest to the present discussion are the consequences of such an input format upon the serial position analysis. The manipulation therefore permits the direct examination of whether any within-list effects produced by the paradigm are solely the product of presenting new categories with each block, or whether similar effects obtain when re-entry of a previously-presented category occurs.

Stimulus Material and List Construction

Twenty lists, each containing 20 items, were compiled with the aid of the Battig and Montague (1969) category norms. Care was taken during selection to avoid high and low frequency exemplars, and the words were equated for word length as far as possible. Lists were constructed according to the following four conditions : Condition A - 1 Category, 1 Block: All twenty words were drawn from the same semantic category. Condition B - 2 Categories, 2 Blocks: The first ten items were drawn from one category, while the second ten were drawn from a different category. Condition C - 2 Categories, 4 Blocks: As in Condition B, ten items were drawn from each of two categories. However these were then further divided into subsets of five items and interleaved. Thus the two categories alternated every block of five items. Condition D - 4 Categories, 4 Blocks: Every block of five items represented a new semantic category. The four types of list construction are illustrated schematically in Figure 4:1.

Design

A within-subjects design was employed with all subjects performing under all list conditions. Each subject thus received a total of twenty lists i.e. five examples of each condition with one example of each serving as practice. The four practice lists representing each list condition were administered first. The ensuing groups of four lists were constrained to contain one example of each list type, while their order was determined randomly within each group and this was re-randomised for each subject. The relatively small number of replications per condition is brought about by the fairly exhaustive use of categories in this type of experimental design. In order that this should not bias the results, two further refinements were employed. Firstly, the categories themselves were rotated across list conditions to ensure that all categories appeared in all conditions. Secondly, both the order of categories within the multi-category lists and the order of words within categories were randomised anew for each subject.

Procedure

All subjects were tested individually. At the beginning of each session the various types of list condition were explained with reference to a diagram similar to Figure 4:1, and standard free recall instructions were given. Beginning with the practice session lists were then read out to the subject at a rate of $2\frac{1}{2}$ seconds per item as timed by a stop-watch. Each list was preceded by a description of its construction and the word

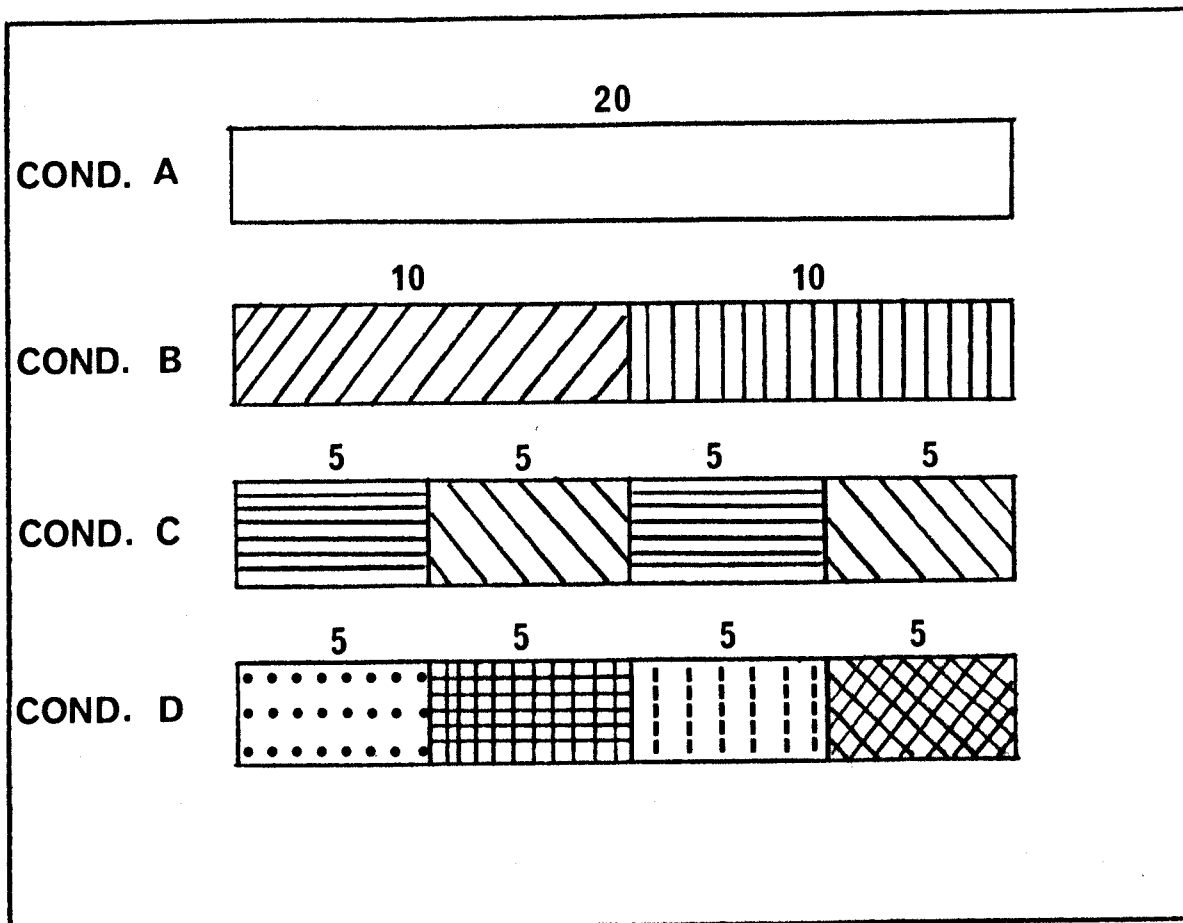


Figure 4:1 Schematic representation of the four types of input list condition.

"ready" which served as a warning signal. At the end of each list a period of 60 seconds was provided during which recall was written in a booklet provided.

Subjects

Eighteen undergraduate students from the Part I Psychology Course at the University of Stirling served as subjects in the experiment. Their participation counted towards a course requirement.

4:3:3 Results

Practice lists were excluded from the following analysis. The results expressed in terms of the percentage of items correctly recalled for each input list condition were as follows: Condition A - 57.5; Condition B - 63.3; Condition C - 62.9; Condition D - 67.1. An analysis of variance conducted on the subjects' raw recall scores showed significant main effects of conditions ($F(3,51) = 7.9, p < .001$), serial position ($F(19,323) = 21.8, p < .001$), and a significant condition x serial position interaction ($F(57,969) = 1.6, p < .001$).

Overall Recall Levels - Blocks versus Categories

If increasing the number of blocks per se is the crucial factor in improving the overall recall levels the expected ordering of conditions would be $A < B < C = D$. On the other hand if the number of categories is the determining factor then the ordering should take the form $A < B = C < D$. Inspection of the percentage scores for each condition given above suggests the latter interpretation is correct. This was confirmed by a Newman-Keuls test carried out on the treatment means which revealed that conditions B and C did not differ significantly from each other while all other comparisons were significant at the $p < .01$ level. Thus within the limitations of the experiment, only increasing the number of categories presented will raise the level of recall performance; no further benefit would appear to derive from subdividing the members of the categories. However this statement requires qualification. While subjects performed best under condition D (four categories) a few subjects occasionally failed to retrieve an entire category. While this occurred only rarely, it clearly limits the generality of the finding and suggests that continued improvement in recall as a function of increasing the number of categories will be governed by efficient retrieval of the category superordinates.

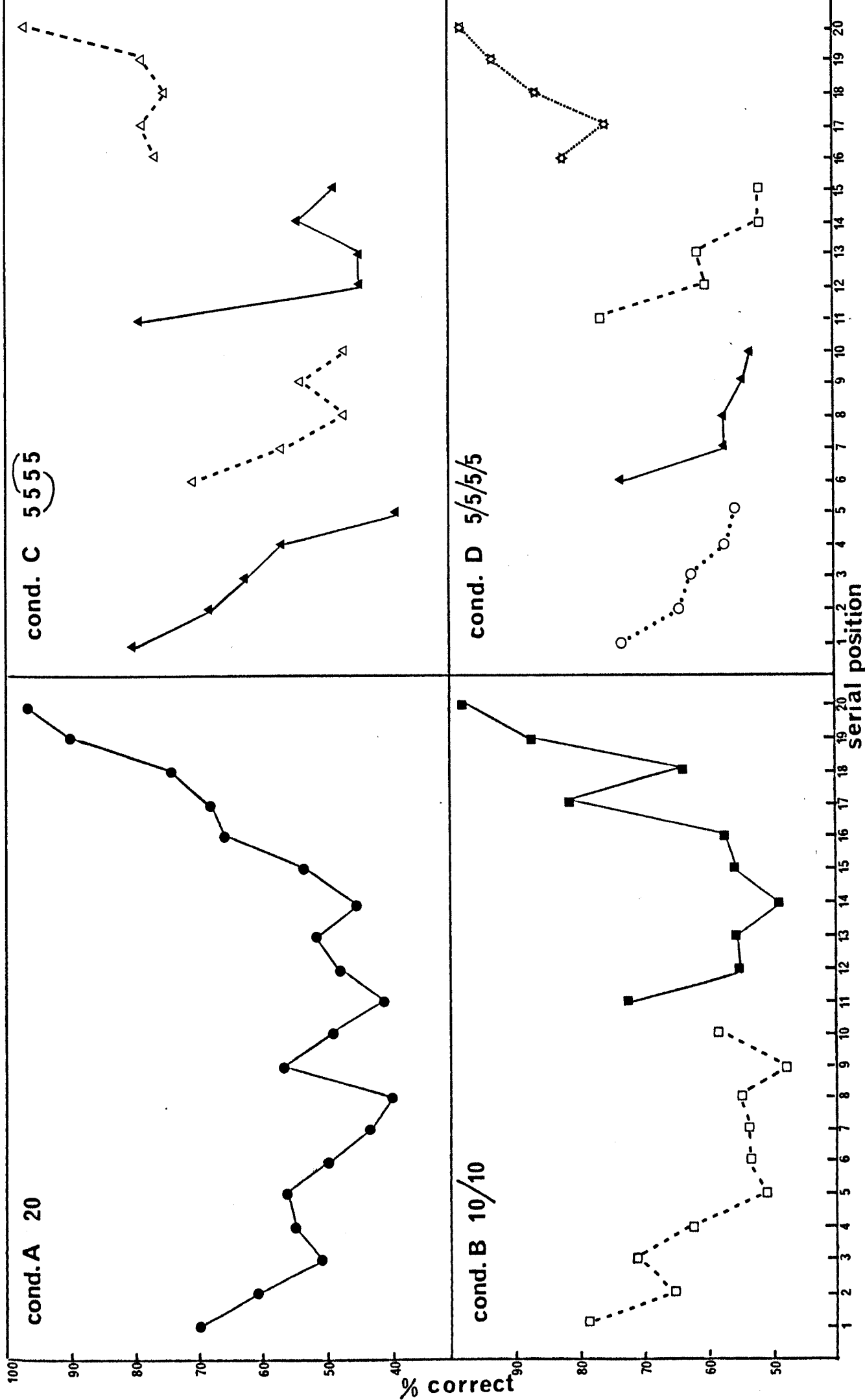


Figure 4:2 Serial position curves for the four types of input list condition

Serial Position Effects

While the results above show that blocking per se does not automatically lead to improved retention unless each block represents a new category it clearly does have an effect upon the microstructure of recall. Figure 4:2 shows the serial position curves for the four conditions of input-list structure. These data, plus the significant conditions x serial position interaction noted above highlight changes in the recall profile which appear to be contingent upon each block. In particular, inspection of the functions depicted in Figure 4:2 indicates that the beginning of each block shows evidence of primacy, and that this occurs whether the group constitutes a new category or merely a subgroup of a previously-presented category (cf Condition C). On the other hand there is no evidence of recency other than that normally obtained for terminal list positions.

4:3:4 Discussion

Discussion of the results will be dealt with under three broad headings: (i) Their relation to previous work on the recall of categorised material; (ii) How they compare with the findings of the Murdock and Carey (1972) study which was the inspiration for the current series of experiments; (iii) Whether or not they uphold the predictions derived from the models as outlined in the Introductory Section. Some of the points raised will be dealt with only briefly here, a full discussion being reserved until after the results of Experiment 6 have been presented.

(i) Comparisons with previous work on categorised material: The results are in general agreement with the body of evidence already accumulated on the recall of related material, while the method of analysis adopted provides valuable additional information. Firstly, the effect of blocking related items from several categories is not only superior to random presentation (Cofer, Bruce and Reicher 1966) but also appears to be superior to recall of a single category (cf Condition A). Secondly, increasing the number of categories increases the level of recall, while the occasional omission of whole categories from the recall in Condition D suggests a retrieval limitation to this advantage. A similar finding was also reported by Dallett (1964). It seems highly likely that these two results are directly related. Inserting additional categories will improve recall provided that the categories themselves can be remembered. It has been shown, for example, that if at least one word can be recalled from a given category, then a roughly constant proportion of words from that category tend to be recalled (Cohen 1966; Mandler 1967). However, presumably there comes a time when increasing the number of categories within a list begins to approximate the situation

facing a subject presented with a list of unrelated items. That is to say that unless the superordinate labels are themselves linked in some way, then the task of actively relating them becomes necessary - a sort of second-order encoding task overlaying that of encoding the individual items. Just such an arrangement is suggested by Mandler (1967) who also stresses the significance of units of five in such a hierarchy.

(ii) Comparisons with Murdock and Carey (1972): Also in accord with the literature was the finding of clustering during recall (e.g. Bousfield 1953). However the inclusion of a serial position analysis considerably extends basic information on the paradigm and provides a direct test of the Murdock and Carey (1972) predictions. On the basis of their results, Murdock and Carey (1972) had predicted both primacy and recency effects should be present for each category block. The results of the experiment reported support this prediction only partially. While each group of related items shows evidence of an apparent primacy effect, recency only obtains for terminal list positions. This tends to reinforce the argument advanced earlier that the Murdock and Carey (1972) recency effects were reflecting some modality-specific phenomenon.

Since Experiment 5 was conducted further evidence of within-list serial position effects using blocked-category lists has been presented by Gorfein, Arbak, Phillips and Squillace (1976). Contrary to the findings of the present experiment these authors claim that each category block exhibited not only primacy, but recency effects as well. This latter claim was based on the significant quadratic trend of an orthogonal polynomial analysis. Such a trend may simply reflect a levelling out of the function rather than any upward turn. As such, the test cannot constitute proof of recency. Indeed close scrutiny of their data reveals that (a) any upward trend for terminal items of a block is very slight, when it occurs at all, and (b) the overall level of any such trend is considerably lower than the accompanying primacy effect.

Therefore it would appear that the recency effect claimed by Gorfein et al (1976) is both qualitatively and quantitatively different from that normally obtained. Indeed if their recall curves had been averaged to smooth out the minor inconsistencies (which are occasionally a feature of serial position functions) it is doubtful whether there would have been any evidence of recency whatsoever.

Assuming this argument is valid, then the only evidence of within-list recency comes from auditory blocks such as those employed by Murdock and Carey (1972) and that seems likely to require explanation in terms of modality-specific storage mechanisms (cf Morton, Crowder and Prussin 1971). For blocked-category lists therefore the only reliable within-list effect appears to be that of primacy for the beginning of each block.

(iii) Theoretical Implications: Turning now to the theoretical interpretations considered in the Introduction, it would appear that these data are handled particularly well by the more detailed formulations of the 2-store approach (Waugh and Norman 1965; Atkinson and Shiffrin 1968). In particular, the Atkinson and Shiffrin formulation which explicitly links control processes capable of responding to changes in the nature of the stimulus material to a reprogrammable rehearsal buffer is completely consistent with the observed effects of within-list primacy. On the other hand each successive category block being processed will tend to act like a delay task in preventing immediate recall of the previous block. Thus recency is only to be expected for the last block i.e. the terminal list positions.

As noted in the Introduction, a levels of processing approach (Craik and Lockhart 1972; Craik and Tulving 1975) has some difficulty in making specific predictions of serial position effects which occur within the pre-recency portion as this is all assumed to reflect semantic (or Type II) processing. In order to account for the present data therefore the theory is required to assume that the initial items in any new category block are somehow more 'elaborately encoded' than subsequent items in the same block. If, in order to do so, the proponents merely wish to fall back upon an explanation based on differential rehearsal (within Type II processing) then the model is hardly different from a dichotomous approach in this respect. If, on the other hand, they prefer to stress differences in the qualitative aspects of the processing (which would appear to represent the essence of their argument more faithfully), then the theory requires to explain exactly how such differences can be achieved within one processing level - particularly the semantic domain.

Of the other theories considered, the positional distinctiveness view of serial position effects would not appear to be supported by the within-list effects. If the blocks of related items are sufficiently distinct from each other to show evidence of primacy effects, then it is hard to see how such an account can explain the lack of corresponding recency effects.

On the other hand the ordinal retrieval strategy hypothesis (Baddeley 1976; Baddeley and Hitch 1977) is embarrassed by the finding of recency for terminal list items. Although the results can be taken as displaying considerable evidence of a retrieval strategy which utilises the semantic relationships amongst the items to guide recall, clearly this does not preclude the normal recency effect.

Finally, the Craik and Jacoby (1975) model has little difficulty in explaining those recency effects obtained in the current experiment as they could be the product either of the primary-memory-type mechanism which holds those items currently being attended to, or of the backward scanning process which can operate in the absence of the former. This

model therefore together with the Atkinson and Shiffrin (1968) model emerge least scathed by the present results, although the latter - because it is a more general theory - offers a more complete picture of the data.

4 : 4 EXPERIMENT 6 : FREE RECALL OF BLOCKED-CATEGORY LISTS : DELAYED RECALL

4:4:1 Introduction

Typically, serial position curves for lists of unrelated words tested immediately after presentation show a small primacy portion, a flat middle section and a large recency component when recall is delayed until after some interpolated task has been carried out, the recency effect is virtually eliminated while the rest of the function remains relatively unchanged (Postman and Phillips 1965; Glanzer and Cunitz 1966). Thus one important characteristic of primacy is its durability. Using blocked-category lists and immediate recall, Experiment 5 has demonstrated apparent primacy effects within lists. If these effects are the product of the same underlying mechanism responsible for normal list primacy, as interpretation in terms of the Atkinson and Shiffrin (1968) model would suggest, then these within-list effects should be equally invulnerable to the effects of a delay task.

At the same time it should be noted that while a levels of processing approach (Craik and Tulving 1975) could not specify easily the fine grain nature of the serial position effects obtained in Experiment 5, it does however suggest that all the items should be relatively resistant to delay. This is because all the items are encoded semantically - the most durable type of processing - and suggests therefore that the functions obtained under delay conditions should not differ markedly from those found in immediate recall. The following experiment therefore was conducted to address this issue.

4:4:2 Method

Stimulus Material and List Construction :

The same lists were used as in Experiment 5 . However, as the focus of examination was that of within-list effects, only those lists employed in Conditions B, C and D of Experiment 5 were utilised.

Design and Procedure :

As before a within-subjects design was employed. In this case each subject received a total of fifteen lists made up of four experimental examples of each of the list conditions plus one practice of each. The only major difference in procedure from that of Experiment 5 was that following presentation of each list a three digit number was read out to the subject. When this occurred the subject was required to count backwards in threes from that number for 30 seconds. Standard free recall

instructions were issued and the nature of the delay task was explained. In particular it was emphasised that the counting task had to be performed as fast as possible during which no thought was to be given to the memory items. As in Experiment 5 lists were read out to the subject at a $2\frac{1}{2}$ second rate as timed by a stopwatch, and 60 seconds was allowed for written recall following the distractor activity.

Subjects

A further group of 18 undergraduate students from the Part I Psychology Course at the University of Stirling took part in the experiment. They received a course credit for their participation.

4:4:3 Results

Practice Lists were again discounted from the main analysis. The percentage of items correctly recalled under each input-list condition are given in Table 4:1, together with the scores obtained from Experiment 5.

The recall scores obtained in the present Experiment in conjunction with the equivalent conditions of Experiment 5 were subjected to analysis of variance with delay serving as a between-subjects comparison. This revealed significant main effects of delay ($F(1,34) = 4.8, p < .05$), serial position ($F(19,646) = 13.7, p < .001$), and conditions ($F(2,68) = 3.9, p < .05$). Once again the condition x serial position interaction was highly significant ($F(38,1292) = 2.7, p < .001$), but of particular relevance to the present discussion, the serial position x delay was also significant ($F(19,646) = 9.9, p < .001$). No other interaction reached significance. The lack of a significant three-way interaction (serial position x condition x delay) shows that delay has the same effect upon serial position, regardless of the different conditions of blocking the input.

Figure 4:3 depicts the serial position curves obtained for the three types of list construction under conditions of delayed recall. From this it can be seen that the effect of delay was to depress the recall of terminal list items; in every other respect the graphs are virtually identical to the comparable conditions of Experiment 5 (cf Figure 4:2). Thus, the effect of delay is to eliminate normal list recency while leaving the within-list primacy effects intact. There are therefore strong empirical grounds for assuming that these primacy effects are mediated by the same mechanism responsible for the superior recall of the early positions in any free recall list.

	2 CATS. 2 BLOCKS	2 CATS. 4 BLOCKS	4 CATS. 4 BLOCKS
EXP.6: DELAY	58·3	56·7	60·6
EXP.5: IMMED.	63·3	62·9	67·1

Table 4:1 Percentage of items correctly recalled
 for each input list condition under
 immediate (Experiment 5) and delayed
 (Experiment 6) recall.

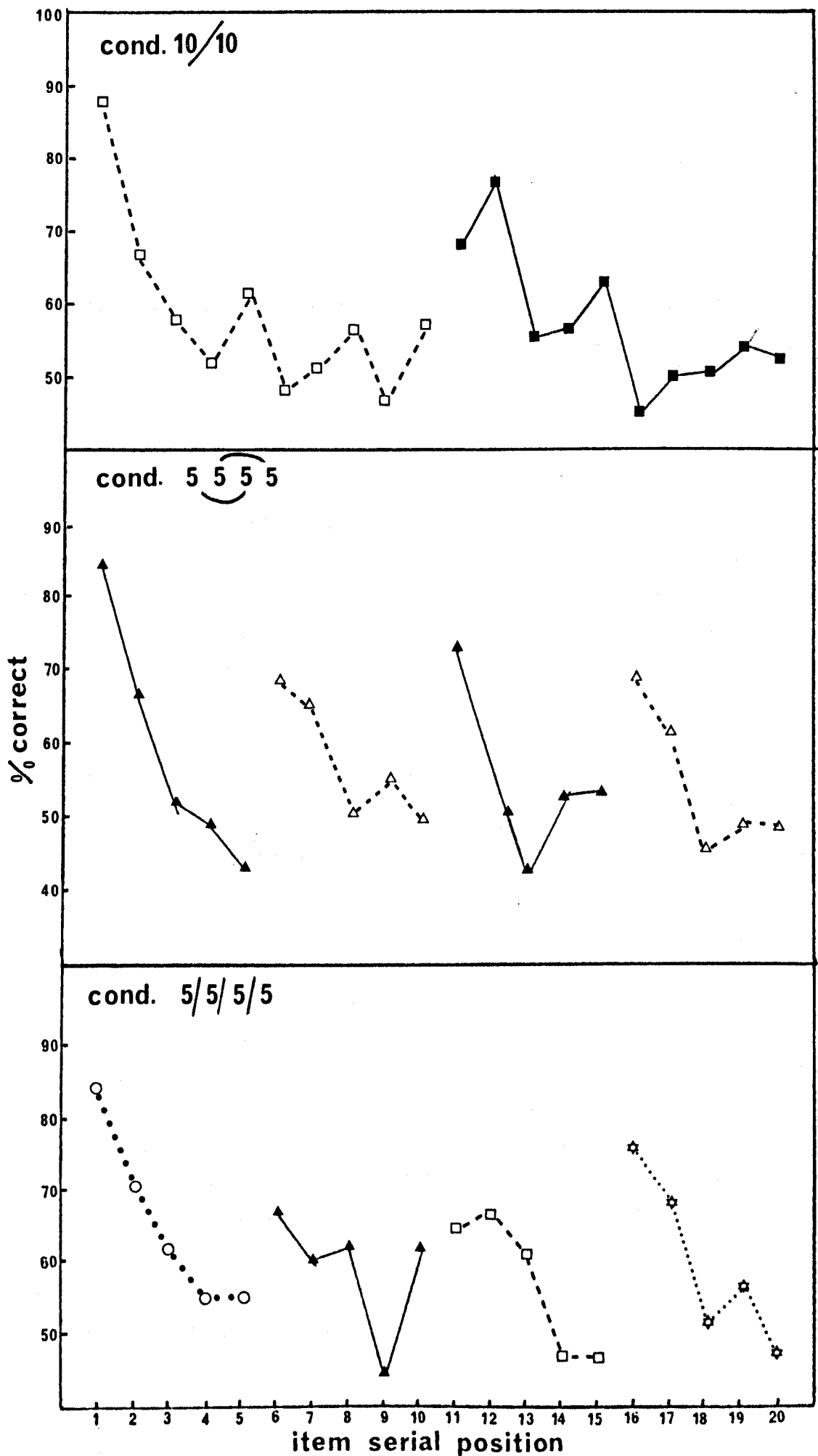


Figure 4:3 Serial position curves for each input list condition (delayed recall).

The results of Experiments 5 and 6 present useful additional information which confirm and extend existing knowledge on the recall of related material. At the same time, the data provide fresh insights into the standard free recall task itself. The demonstration of reliable and durable within-list primacy effects (Experiment 6) is likely to prove of considerable theoretical importance. For instance, at first sight the results might appear to challenge existing conceptualisations based exclusively on the ubiquitous and regular bow-shaped curve. Whether this is indeed the case will be considered below during an examination of the implications of these findings.

4:5:1 Release from Interference

One interpretation of the within-list primacy effects which can be ruled out fairly early is that they are the result of a surprise or startle reaction on the part of the subject (cf Green 1958). In both experiments reported the subjects received practice examples of each type of list construction prior to the main testing session, and further, were briefed about the nature of every list before its presentation. Under these circumstances it seems unlikely that they were taken aback by any unexpected changes in the material during input which might have led to certain items being afforded some privileged status (cf Von Restorff 1933; Gumenik and Rossman 1970).

In their study of mixed-modality lists, Murdock and Carey (1972) attributed their findings of within-list effects to release from interference from both prior items (PI) and later items (RI). Several aspects of the data from both the current experiments and the original study itself would appear to weaken this explanation. Firstly, release from RI was not a feature of the results of Experiments 5 and 6, as this presumably would have required to take the form of recency within the category blocks. Furthermore, Murdock and Carey themselves found release from RI only when going from auditory to visual blocks, but no such effect in the reverse direction. Rather than attempting to incorporate such asymmetry within the release explanation, a more parsimonious interpretation was offered earlier which takes account of a body of other evidence on modality effects (cf Penney 1975). As this phenomenon appears to be tied exclusively to the presentation of auditory blocks it would appear sensible to relate it to the known advantages which accrue to the involvement of some form of auditory store (eg Morton, Crowder and Prussin 1971).

This still leaves the primacy results as being capable of explanation in terms of release from proactive interference effects (eg Wickens 1970). There are, however, certain difficulties also attaching to this account. Firstly, if PI represents a process which gradually builds up, why does performance show evidence of asymptoting rather than continuing to decline under its influence? That this occurs is evident both from the single trial Peterson paradigm employed by Wickens (1970) and the individual items within each block employed in the present free recall studies. More serious perhaps is the fact that the state of proactive interference as an explanation is being devalued through an inability to define the concept in terms of agreed underlying mechanisms. For example, Postman (1975) has reviewed a number of recent studies and arrived at the conclusion that the phenomenon is still poorly understood. Indeed, if anything understanding appears to be decreasing as analysis in terms of conventional interference principles is no longer tenable (Postman 1975, p.307). In appealing to a 'release from PI' account (which would certainly fit the data) there is the danger therefore that one is merely supplying the effect with a label, rather than providing an adequate explanation.

4:5:2 Levels of Processing

Difficulties with the levels approach have already been encountered. As noted earlier with reference to the within-list primacy effects, the lack of specific detail concerning possible differences within the semantic level make specific prediction difficult. Indeed it can also be argued that there is probably even a problem with definition of the term 'semantic processing' itself, and that this can cause problems with recency explanations is evident from the following.

As an illustrative example, take the group of semantically-related items 'Sparrow, Eagle, Blackbird, Parrot, Thrush'. One simplistic account of the subjects processing of such a group would be assume that the items are all encoded as being examples of the superordinate category 'Bird'. Thus during acquisition the subject establishes that the items are associated with one another and are all linked to a higher order descriptive label. For most researchers this would constitute a clear example of a form of semantic processing. If one further assumes that the above group of items constituted the last category block in a Condition D list in the experiments just described then certain results and implications follow.

Firstly, under conditions of immediate recall these items would exhibit a substantial recency effect (Experiment 5) which is eliminated by a period of filled delay (Experiment 6). Now the levels of processing account seeks to explain free recall recency effects and their removal by interpolated

tasks by assuming that these items receive only superficial (phonemic) encoding which contributes very little to long-term retention. Taking the argument one stage further, this appears to lead to one of two possibilities: (i) Either the terminal items 'Blackbird, Parrot, Thrush' were not encoded as 'Birds' or at least were not semantically linked during acquisition, or (ii) The form of processing described above is not 'semantic' in the sense in which Craik and Lockhart (1972) wish to imply. The first of these possibilities seems extremely ^{unlikely}, while there is simply not enough precision within the model to evaluate the second statement adequately. Furthermore, since the model neglects retrieval considerations it cannot surmount this difficulty by appealing to any short-term retrieval strategy which could be applied to terminal items in immediate recall, regardless of how they had been processed.

Thus it has to be concluded that there are difficulties with interpretation of the model when detailed prediction is required. In addition these problems seem evident whether one considers the earlier (Craik and Lockhart 1972) or later (Craik and Tulving 1975) versions of the theory.

The model's greatest success with respect to the present data would appear to be that, in general terms at least, it would undoubtedly predict the durability found in the delay condition: Given that items have been encoded semantically their long-term retention is therefore likely to be extremely good. This of course accounts for all except the terminal list items referred to above.

4:5:3 The Modal Model

As intimated in the brief discussion following Experiment 5, the data on the immediate recall of blocked-category lists are completely compatible with the Atkinson and Shiffrin (1968) theory. The same can now be said of the results of the delay condition employed in Experiment 6.

While on the surface, the model appears to be somewhat mechanistic with rigidly defined structures, the stressing of the function of control processes removes any impression that the organism merely acts as a passive information receiver. These control processes perform an active selection operation on the items to be rehearsed within the buffer, and will do so in accordance with a particular plan. It is therefore only a small step to assume that in the blocked-category paradigm this process makes use of the organisation already present within the list material. In this way the rehearsal buffer is directed to reset and commence circulation of material each time a new block is presented. Thus each block is treated in a similar fashion to the way in which a normal free recall list of unrelated material is handled, although the categorised nature of the former provides additional encoding possibilities.

This account clearly predicts durable primacy for early items within each block as these items have received a greater number of rehearsals and therefore are more likely to have entered LTM. On the other hand the items currently being rehearsed at the time of recall will be output from the buffer giving rise to the recency effect. In addition the limited capacity of the mechanism and the operation of the displacement principle both account for the size of the recency effect in immediate recall and its elimination by interpolated activity.

Moreover, this approach is consistent with (a) known patterns of rehearsal operation during typical free recall (Rundus and Atkinson 1970) and (b) those involved in dealing with categorised material where related items are drawn together within the same rehearsal groupings (Rundus 1971).

4:5:4 Alternative Accounts

As indicated in the discussion of Experiment 5, of those additional part-theories considered, only the Craik and Jacoby (1975) account is completely consistent with the data. This is still the position after the results of Experiment 6 where the delay task both removes terminal list items from conscious attention, and simultaneously renders the backward scanning process inadequate owing to the large amount of intervening items.

The free recall of lists containing blocks of semantically related items was examined under conditions of immediate (Experiment 5) and delayed recall (Experiment 6).

The number of categories was found to be the prime determinant of the overall level of recall as opposed to the number of blocks per se. More categories produced superior recall, although this trend seemed likely to be limited by the ability to recall the category labels.

Presenting related items in blocks altered the recall profile as witnessed by serial position analysis; and this occurred whether the block comprised all the items from a new category, or merely a sub-set from a previously-presented category. These effects were characterised by within-list primacy contingent upon the beginning of each block.

Various theoretical positions were examined to determine how well they could account for such data. Of the theories devoted exclusively to recency, the Bjork and Whitten (1974) model is, by its own definition, inadmissible where items are cumulatively rehearsed, while the version of the ordinal retrieval strategy considered (Baddeley 1976; Baddeley and Hitch 1977) would appear to be refuted by the finding of recency for events with high inter-item association. Craik and Jacoby's (1975) account however was consistent with the findings.

Of the formulations designed to explain both primacy and recency, the positional distinctiveness model was not supported owing to the asymmetry of the effects obtained. This leaves the two major approaches represented by the levels of processing approach, and the versions of the Modal model. A lack of precision in the former proved the major stumbling block in arriving at detailed prediction, especially regarding serial position effects, and the apparent inconsistencies were noted. The version of the modal model proposed by Atkinson and Shiffrin (1968) however appeared to offer the best overall account of the findings.

The next section will examine whether this is still the case when the paradigm is altered very slightly to afford an opportunity of obtaining still further recency effects.

A great deal has been made of the recency effect in free recall and its crucial role in dichotomous views of short-term memory function. Traditionally this has been based on studies of the recall of lists composed of individual words. Few researchers have considered the possibility of recency effects for units larger than the word. Such a finding, if it proved to be demonstrable, would be theoretically important as it would appear to cast doubt on the many interpretations of recency which implicate the operation of a small capacity system limited to a few words.

4:7:1 Recency for Individual Words

When a list of words is presented for immediate recall the terminal items are recalled best. This recency effect normally spans the last three or four items, although it can be shown over the last six (cf. Murdock 1962). If an interpolated task intervenes between presentation of the material and the recall phase, the effect is eliminated (Postman and Phillips 1965; Glanzer and Cunitz 1966). This has led many to conclude that recency represents the output from a labile, fixed-capacity short-term store (Waugh and Norman 1965; Glanzer and Cunitz 1966; Craik 1968; 1971) or a similarly limited rehearsal buffer (Atkinson and Shiffrin 1968). Although other interpretations have been held (eg Postman and Phillips 1965; Tulving 1968; Craik and Lockhart 1972) the above represented the most commonly agreed theoretical position.

More recently however data have been presented which challenge this view. Amongst the various pieces of contrary evidence two particular categories can be identified viz. (i) studies which appear to violate the short-term principle and (ii) studies which appear to violate the limited capacity principle. The evidence for long-term recency phenomena will be considered in more detail in a later section; for the moment attention will be focussed on those studies which question the recency effect as reflecting a mechanism of extremely limited capacity. In this context, some of the most compelling evidence comes from experiments which employ a subsidiary task which has to be performed during presentation of the memory list. The logic of the situation is straightforward: If recency represents the output from a limited capacity store, and if the same store is now required to perform additional holding operations, then recency should be severely impaired. That this is not the case is demonstrated clearly by the following experiments on concurrent task loading.

For example, Murdock (1965) required subjects to perform a card sorting task while processing a to-be-remembered list. Increasing the difficulty of the additional task caused a progressive deterioration in recall performance over the early parts of the retention function but had no comparable effect on the recency component. A similar result was obtained by Baddeley and Hitch (1974). Their subjects attempted to memorise a standard free recall list presented to one modality while performing a digit copying task presented to the other modality. Three levels of storage load in the digit task were achieved by having subjects either copy down each digit as it was presented (storage load 1), or only after three digits had appeared (storage load 3), or after six digits (storage load 6). The result of particular interest is that the recency effect remains relatively intact even when there is an additional load of six items - a figure at least twice as great as the majority of estimates of the capacity of the short-term store based on free recall (eg Craik 1971; Glanzer 1972; Watkins 1974). Furthermore, Baddeley and Hitch (1974) found that the same result obtained whether the subsidiary task was presented via the visual modality and the memory list auditorally or vice versa. Essentially the same finding has been demonstrated with arithmetic as the subsidiary task (eg Shiffrin 1970). Taken together these results argue against recency being equated with a limited-capacity store.

In addition, Richardson and Baddeley (1975) have presented data which show that the recency effect is still present even though their subjects were required to repeat some redundant items out loud during presentation of the memory list. This articulatory suppression technique (Murray 1968) is assumed to pre-empt the use of any speech-based system during presentation. Hence the data strongly challenge the notion that recency is the output from a rehearsal buffer, (Atkinson and Shiffrin 1968) which one supposes is predominantly articulatory in nature.

In passing it should be noted that the above findings are completely consistent with the findings on rehearsal patterns as obtained with the overt technique (Rundus and Atkinson 1970). The number of times an item is rehearsed decreases monotonically as a function of its input serial position. Early list items are continually reincorporated within rehearsal groupings as the list is presented, while later items receive very few rehearsals. That is to say that the rehearsal operations performed during the presentation of terminal items are predominantly occupied with items from earlier parts of the list. Under conditions of having to perform an additional task it is quite reasonable to suppose that the major impairment comes about by denying the early items some of the extra rehearsals they would receive normally. Recency on the other hand is likely to be unaffected

as the terminal items merely receive the same - albeit minimal - number of rehearsals.

These comments notwithstanding, the results from studies using concurrent loading tasks damage the equation of recency with a limited capacity mechanism, whether this is considered to be a store (Waugh and Norman 1965; Glanzer 1972) or a form of rehearsal buffer (Atkinson and Shiffrin 1968).

Another, indeed a related approach, is to consider whether recency effects can be demonstrated for larger units than have been considered to date.

4:7:2 Recency for Larger Units

The first indication that recency may be independent of unit size comes from studies which varied the length of the words making up the memory list. For example, Craik (1968) showed that word length had no effect upon the recall of terminal items, but did have an effect upon earlier items such that shorter words were recalled better. Essentially the same result emerges from experiments by Glanzer (Glanzer 1972; Glanzer and Razel 1974). These studies show similar recency effects for monosyllabic, disyllabic and even compound words. Still more dramatic is these authors' discovery of recency for proverbs and simple sentences. Taken together these results appear to indicate an effect capable of extending over a great many more intervening events than the usual demonstration of recency for unrelated words suggests. On the face of it therefore an explanation of recency based on a limited capacity STS seems untenable. Glanzer and Razel (1974) attempted to counter this argument by assuming that while the store itself is limited in terms of the number of units it can hold (now revised downwards to 2), the size and complexity of the units may vary. Such an account which simultaneously places severe limitations on the number of units and considerable flexibility on their size seems implausible for several reasons. Firstly, one might reasonably ask why such a mechanism cannot reallocate the resources normally devoted to handling large and complex units to include several more items when the units are as simple as single words. Secondly it is difficult to accept that the contents of the store which normally can be displaced by as few as four subsequent distractor items (Glanzer, Koppenaal and Nelson 1972) somehow are preserved when a great many more (albeit 'relevant' memory items) have to be processed. (Incidentally there is some evidence to suggest that the recency effect obtained for proverbs is a long-term phenomenon. Without dwelling further on this point, it is sufficient to note that such a result would be equally damaging to Glanzer's argument as it violates the short-term principle). Finally, Glanzer's explanation

fails to take account of the substantial body of results (reviewed by Baddeley 1976) which show the effects of particular variables on a wide range of STM tasks, and also on reasoning and comprehension performance (Baddeley and Hitch 1974) but have no comparable effects on recency. If the role of a short-term store, or working memory, is implicated in the former set of results, and the same mechanism is responsible for recency, then it too should prove susceptible. That it is not clearly damages the credibility of such a theory.

Thus while there was originally good reason to suppose that versions of the modal model were competent at handling the data from the experiments presented previously, there is clearly other evidence which casts doubt upon such an interpretation. However, rather than following the reasoning advanced by Baddeley (1976) above, a somewhat different line of enquiry is being pursued here. One reason for the apparent early success of the model might have stemmed from its application to experiments where only recall of individual items was being tested and measured. Clearly if larger units than single words are involved in the effects then the situation facing the theory would not be so straightforward.

In this context, alternative accounts of recency which stress the operation of a particular retrieval strategy may have to be reexamined, given that they are presumably less constrained by a limited-capacity mechanism. Certain difficulties with these approaches have already been noted. However this does not imply that suitable modifications could not be made to such theories. The question then becomes one of whether such modifications are more easily accommodated within these theories than the alterations which might be forced upon the modal model.

However, returning to the earlier discussion it is perhaps premature to conclude that recency for units larger than individual words has been demonstrated convincingly. For example, the experiment using proverbs - Glanzer (1972) - is open to the objection that perhaps only one or two 'key' words require to be encoded in order to identify and retrieve each saying. While the same criticism cannot be levelled as strongly at the experiment with simple sentences, clearly they too enjoy considerable redundancy. A much more effective demonstration therefore would be the finding of recency for categories within the blocked-category paradigm employed in Experiments 5 and 6. In such a case, while retention of the category superordinates may well be crucial for effective retrieval (Tulving and Pearlstone 1966), such labels could not serve as 'complete cues' in the way that the key words of a proverb might. For example, the category of Christian names contains hundreds of examples; unless the specific instances presented in a memory list were attended to and suitably encoded, the chances of recalling them correctly would be extremely small.

If it could be demonstrated then, the findings of a recency effect for category blocks would be of considerable theoretical importance. Firstly on the basis of the arguments outlined above, it would further confirm that the effect can occur where an explanation which ties recency to the operation of a limited capacity store (Waugh and Norman 1965; Craik 1971 ; Glanzer 1972) can be ruled out. Similarly, an explanation based on the output from a rehearsal buffer would appear to be inadequate (Atkinson and Shiffrin 1968). Finally it would tend to support the growing body of evidence which favours the operation of a specific retrieval strategy which can be directed either at individual words, or distinct groups of items, whichever is appropriate to the task in hand.

With this in mind, it would seem appropriate to re-examine the data obtained in the four category condition used in Experiments 5 and 6. Indeed Figure 4:2 panel D shows that the levels of immediate recall for category blocks exhibit tentative evidence of a bowed shape. This is further confirmed by an analysis which disregards the individual items and records only the number of categories recalled. For immediate recall this yields figures of 63, 61, 62, 72 for each input block respectively. (The total possible is 72). Moreover the comparable scores for the delayed recalled condition of Experiment 6 are 63, 60, 61, 67. Thus the number of categories recalled for the initial three blocks remains virtually unchanged from immediate to delay conditions. The fourth block however is always recalled under the immediate condition but drops by approximately 7 % when recall is delayed. Superficially this might be taken as indicating a recency effect for category superordinates which operates in immediate but not in delayed recall. However the argument is highly speculative. In the first instance the effect only extends over the last category block and this may be merely the product of recalling the terminal items first - a situation not afforded the delay subjects. Also, the data on category recall shows that retention is fairly high for all blocks and may therefore be suffering from ceiling effects. The most limiting factor however is that the experiments only employed lists composed of four category blocks - too small a number to test the hypothesis being considered here. In the experiments to be described therefore, 60-item lists were constructed (with each list containing 5 instances of each of 12 different categories) in order to provide maximum opportunity of testing for the effect. In addition two further conditions were included in the design. Firstly control lists containing the same items randomly distributed were presented to different subjects; and secondly a final free recall test (Craik 1970) was administered at the end of the sessions in order to determine the nature of any long term effects. It was anticipated that these refinements would permit a more complete account of the results obtained.

4:8:1 Method

Stimulus Material and List Construction

Lists were constructed with the aid of the Battig and Montague (1969) category norms. Care was taken to avoid both high and low frequency exemplars and an attempt was made to equate the word length of the instances chosen across categories. Apart from these preconditions selection was conducted on a random basis. Each list contained 60 items made up of 5 instances of each of 12 different categories. For the blocked condition, lists were constructed such that all 5 exemplars of any one category were presented before a new category appeared. In this way four basic lists were compiled. These were then permuted to produce 4 sets of 4 lists, to be presented to the different subgroups of subjects. This randomisation was carried out by altering the categories contained within any one list and also the order of the words within each category (while preserving the blocked nature of the presentation format). For the random condition the same 4 sets of 4 lists were employed. However in this case the words within each list were rearranged to remove the blocked nature of the organisation. This randomisation was carried out with the constraint that one example of each category should appear within each group of 12 items.

Design and Procedure

A between-subjects design was adopted such that one group of 20 subjects received the blocked lists while a different group of 20 subjects were presented with the random lists. Within these two main groups subjects were tested in sub-groups of five, with each sub-group receiving one of the 4 sets of lists described above. Prior to the testing session the nature of the free recall task and the construction of the lists they would encounter was fully explained with the aid of a blackboard diagram. No practice lists were administered owing to the lack of any remaining categorised material.

The lists were read out to the subjects at a rate of $2\frac{1}{2}$ seconds per word as timed by a stopwatch. Following presentation of each list four minutes were allowed for recall which had to be written in a response booklet provided. Subjects were instructed to write their recall, one word per line, vertically down each page. A fresh page was provided for recall of each list.

Once recall of the last list had been completed the response booklets were collected by the Experimenter and subjects were given a phoney debriefing which lasted 3 minutes. Following this, an unexpected recall test was administered during which subjects were asked to recall as many words as they could from the entire previous session. Fresh response sheets were provided for this activity.

Prior to their leaving the group testing room, subjects were requested to refrain from discussing the experiment with any colleagues who might serve as future subjects.

Subjects

A total of 40 undergraduate students from the Part I Psychology course at the University of Stirling acted as subjects in the experiment. All received a course credit for their participation. None had previously taken part in any memory experiment for the author. Twenty were assigned randomly to the blocked-list condition and twenty were allocated the random condition.

4:8:2 Results

Scoring : Immediate Recall (IR)

Immediate recall scores were calculated for each input serial position for both groups of subjects. These data, expressed as percentage correct scores are depicted by the upper curves of Figures 4:4 and 4:5 for the blocked and random presentation conditions respectively. Examination of the blocked-condition function again reveals the within-list primacy effect previously obtained in Experiments 5 and 6. The comparable random condition function reveals no such consistent effect, and the curve though somewhat 'noisy' is essentially similar to that obtained in typical free recall. In order to simplify the analysis these data were expressed in terms of groups of 5 items, and this is shown in Figure 4:6 (upper panel). For the blocked condition this corresponds to each category presented during input, while for the random condition it merely represents pooling every 5 consecutive items. As this form of collapsing does not appear to violate any other effect in the random case (as depicted by the full serial position function of Figure 4:5), and as it permits a direct comparison with the blocked categories it was felt that such an analysis was justified.

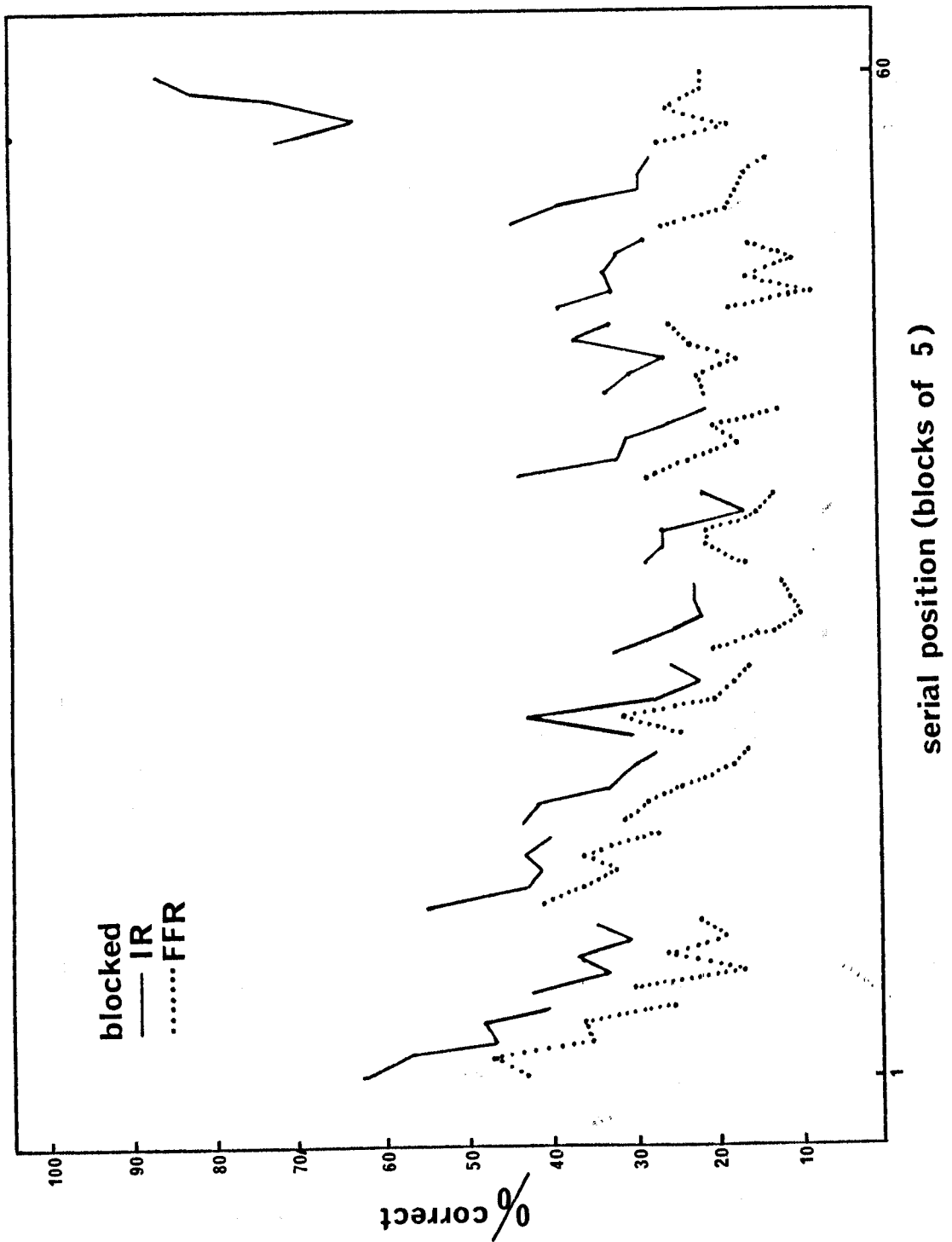


Figure 4:4 Serial position curves for the blocked condition lists under both immediate (IR) and final free recall (FFR).

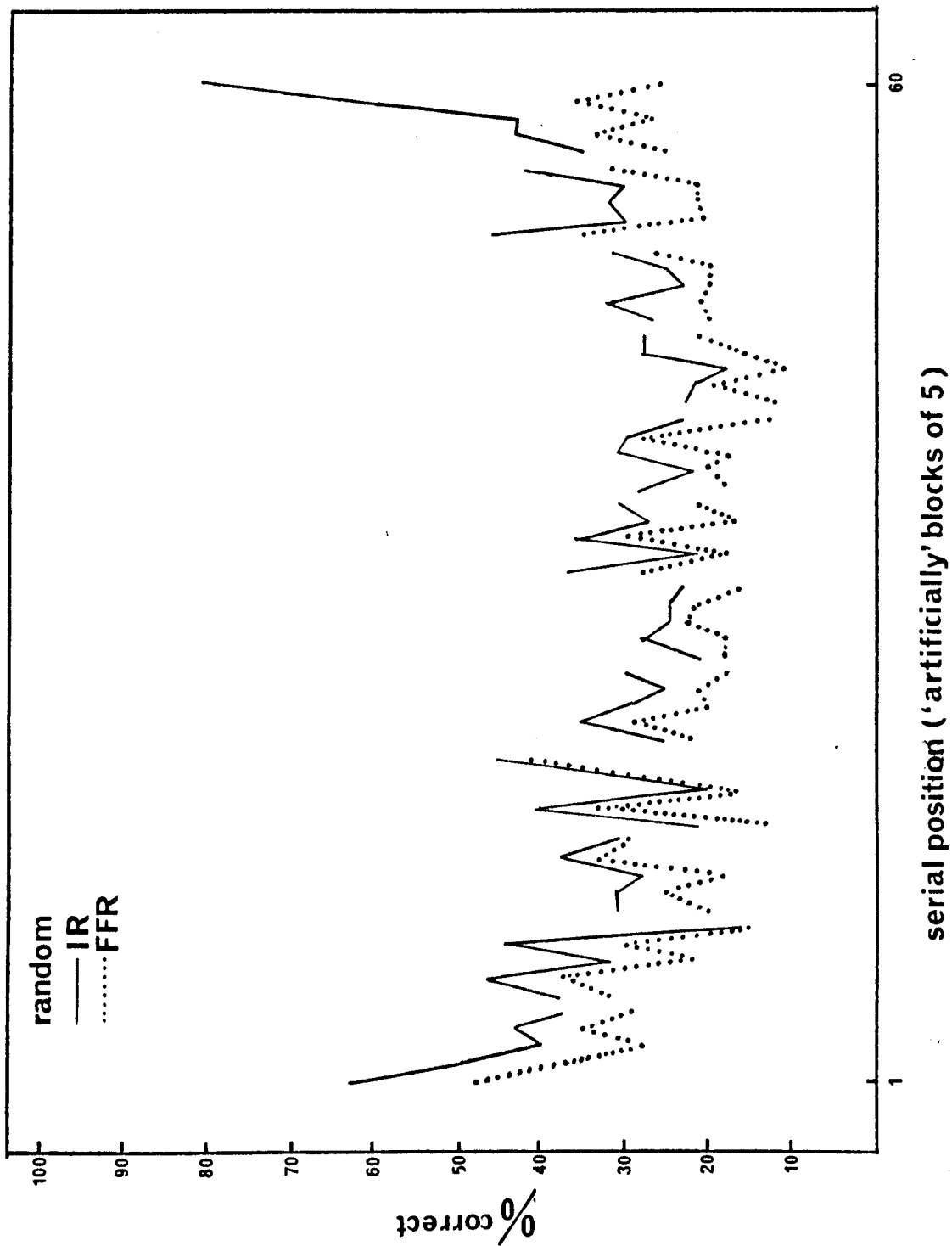


Figure 4:5 Serial position curves for the random condition lists under both immediate (IR) and final free recall (FFR).

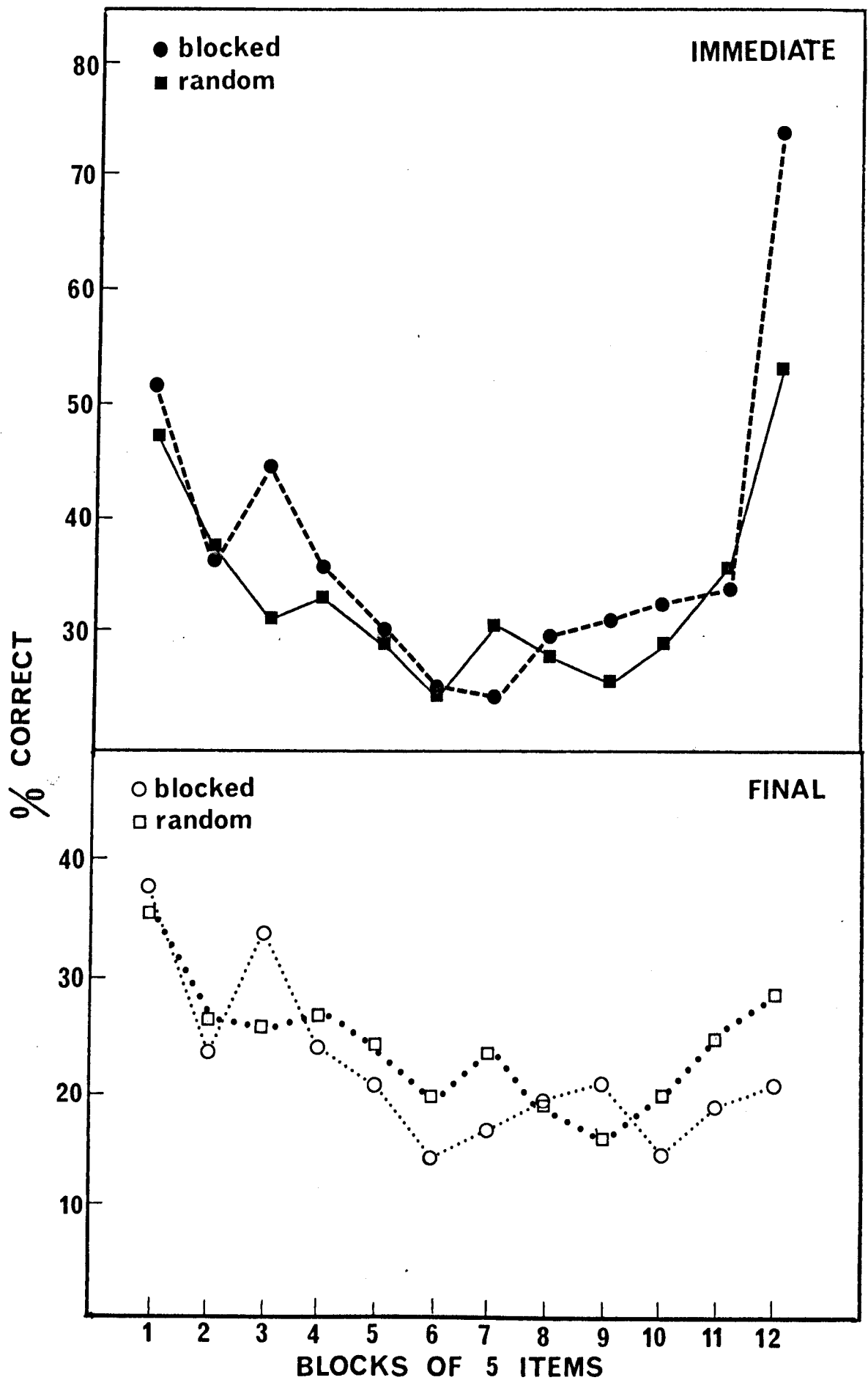


Figure 4:6 Serial position curves for both blocked and random list conditions collapsed over groups of 5 items. Upper panel - immediate recall; lower panel - final recall.

Scoring : Final Free Recall (FFR)

A similar exercise to that conducted on the immediate recall scores was carried out on the results of the unexpected recall test administered at the end of the main testing sessions. In this case only those items which were recalled during IR were included in the analysis. This conditional scoring technique is the conventional method for handling such data as it permits a more realistic and unconfounded assessment of the durability of items recalled earlier (Craik 1970). In any case the proportion of 'reminiscence' items - those items recalled during FFR which were not recalled in IR - is generally fairly low. In the present experiment the figure was of the order of 3 per cent. The results of this analysis are shown graphically in the lower panel of Figure 4:6.

Analysis of variance was conducted on the raw scores from the collapsed data procedure noted above. List condition was treated as a between-subjects variable, while serial position and delay were included as within-subjects comparisons. This revealed that the main effect of list condition was not significant ($F(1,38) < 1$) while those of delay ($F(1,38) = 103.63, p < .001$) and serial position ($F(11,418) = 15.78, p < .001$) were both highly significant. As expected the delay x serial position interaction term was also highly significant, ($F(11,418) = 33.64, p < .001$) and as Figure 4:6 indicates the loss due to delay was proportionally greater for later blocks of items. However, the list condition x serial position term failed to reach significance ($F(11,418) = 1.69, p > .05$). On the other hand the condition x delay interaction did reach significance ($F(1,38) = 6.05, p < .05$) indicating that delay did not affect the two types of list equally. This would appear to be borne out by the significant three way interaction list condition x delay x serial position ($F(11,418) = 6.93, p < .001$). Scrutiny of Figure 4:6 on this point suggests that the slight superiority experienced for blocked-condition lists in immediate recall is lost during the retention interval, and that this is more likely to be the case for later groups of items. Thus the interactions might be taken as offering tentative evidence in favour of a position which claims immediate recall superiority for presenting related items in blocked format. However it must be admitted that the analysis of the results, and the evidence of Figure 4:6 are less conclusive than full support of the hypothesis might demand. Possible reasons for this situation will now be entertained.

Full consideration of all the issues raised by Experiment 7 will be postponed until the General Discussion section embracing the results of both this and the following Experiment. For the moment the focus will be consideration of the results in so far as they bear on the prime reason for conducting the experiment viz whether or not recency for units larger than individual words can be demonstrated. On this specific issue however the evidence presented seems somewhat inconclusive.

Firstly, it should be noted that the lack of a significant difference between the two types of list format is not of itself particularly damaging to the hypothesis. This result may well be due to a general failure by both groups to retrieve all the categories presented. Indeed, that this was likely to occur beyond 4-category lists was anticipated previously in Experiment 5. However the most general form of the retrieval strategy theory requires, presumably, that the blocked condition exhibit superior immediate recall performance at least for terminal groups of 5 items. While the upper panel of Figure 4:6 indicates that there may be a trend in this direction, the difference is fairly small; is not present at all for the second last block; and is only really substantial for the very last group of five items. Also, the significant three way interaction (presentation condition x serial position x delay) might be taken as offering partial support to the hypothesis as it suggests that the blocked condition is superior to the random condition in immediate recall (but inferior to it in final free recall). However, reference to Figure 4:6 again shows that this IR superiority is as likely to have been determined by earlier list positions as later ones. Therefore while the data do not exclude a theory of recency based on a retrieval strategy capable of handling large units, clearly no very firm evidence in its favour can be said to have been found. For example one possible explanation for the lack of a convincing effect which still preserves the general hypothesis would be to assume that recall interferes with retrieval. That is to say that the act of recalling items from any one category (eg the last block) detrimentally affects possible access to other terminal blocks. Presumably this could occur in much the same way as recalling early list items first eliminates normal recency for unrelated words (Tulving and Arbuckle 1966). Although such an account is plausible several factors would seem to weaken it as a theory. Firstly there is the obvious point that on the basis of the present experiment the explanation is merely post hoc. Secondly it would appear to be difficult to test in the context of typical free recall, and may therefore require the adoption of a form of serial probe technique (Waugh and Norman 1965). Thirdly, if the mechanism is indeed always susceptible to output interference, and this is always generated by the

recall of items from the terminal block, then clearly there would be very limited opportunities for demonstrating the usefulness of such a construct. In the light of these observations it would appear to be more prudent therefore to reserve judgment on the issue until more positive evidence is forthcoming.

A more fruitful line of enquiry is opened up by several features of the data which tend to suggest that optimum recency may not have been achieved in the experiment. For example the immediate recall curves of Figure 4:6 show that the terminal group of 5 items in the blocked condition was recalled correctly just over 70% of the time. This does not compare favourably with the results obtained in the 4-category condition of Experiment 5 where all the items within the last group bar one lay between 80 and 100%. Furthermore the random condition in the present experiment shows even poorer recency performance with a score of just over 50% for the last five items. That this is not merely the misleading result of a few high scores being pulled down by several low scores in an averaging process is borne out by the full serial position data of Figure 4:5 (upper curve). From this it can be seen that the last two serial positions attain levels of 81 and 65% respectively. Such levels are substantially lower than those obtained in typical immediate free recall and therefore suggest that the usual pattern is not being adhered to. Confirmation of this comes from the output order of recall. Examination of subjects' response sheets reveals that they were not consistent in recalling terminal items first. This trend was most marked in the random condition where subjects clearly used the categories to guide their recall as described earlier in considering the work done by Bousfield and his associates (Bousfield 1953; Bousfield, Cohen and Whitmarsh 1958). Evidently in the present experiment this strategy was carried out at the expense of full terminal item recall. As an essential prerequisite of recency involves recalling the last items as soon as presentation ceases, this would be bound to reduce the usual levels attainable. Given that this has occurred in the random condition where a typical large recency effect would be anticipated if all terminal items had been recalled first, it is just conceivable that a similar effect operated in the blocked condition, thus pre-empting the demonstration of a convincing recency effect over blocks. That is to say that just because substantial recency for blocks was not achieved, it does not follow that the retrieval strategy theory is invalid. It may be the case that other factors may have led subjects to adopt alternative strategies which in their turn have precluded its operation. At least three possible reasons can be advanced for the atypical recall output order obtained in the present experiment, and which would tend to support this argument.

- (i) Firstly, as noted above, other compelling factors may have induced atypical recall strategies which deviate from the free recall norm. In the experiment conducted the use of categorised material has tended to produce a clustering during recall (eg Bousfield 1953) and this clearly interfered with the usual tendency to recall all terminal items first in the random condition. This finding would be predicted by Baddeley (1976).
- (ii) The use of extremely long lists may result in a tendency for subjects to adopt more of a serial order recall. This could occur if subjects become concerned that items presented very early in the list may be forgotten if they are not output early in recall. Although it should be noted that the use of long lists per se does not always lead to reduced recency as evidenced by the functions obtained by Murdock (1962) for 40-item lists. However the final possibility may help to explain this discrepancy.
- (iii) Owing to the exhaustive use of categories in the present experiment, subjects were tested only on four lists. Evidence presented by Dallett (1963) and Keppel and Mallory (1969) suggests that recency superiority only develops over successive lists. The four lists employed therefore may have been insufficient to establish the typical stable patterns of terminal items being recalled first.

It should be noted in passing that the same criticism cannot be levelled at Experiment 5. Although in that case only 5 lists (including one practice) were employed per condition, there were 4 list conditions. Thus subjects experienced 20 lists in all and this was presumably sufficient to stabilise recency performance, while the randomisation procedure adopted ensured that any such developing strategy would not bias the results against any particular condition.

As some of these effects are known to have applied in the experiment and the others may have occurred, there are good grounds for assuming that only sub-optimal recency was obtained. On the basis of these arguments therefore it was decided to carry out a replication of the experiment using instructions to the subjects to recall as much as possible from the end of the list prior to recalling any other items. If under these circumstances the level of recency attained in the blocked-format condition remains unchanged then it can be assumed that the retrieval strategy theory is in need of modification to explain why larger, distinct units are not encompassed easily. In any case, whatever the outcome, the experiment should produce results which are less equivocal than those of the present study, as subjects are specifically tasked to output the items and groups of special interest first. The failure to find the effect can be more directly attributed to the inoperability of the proposed mechanism as it ought not to be confounded by alternative strategies.

4 : 9 EXPERIMENT 8 : FREE RECALL OF BLOCKED-CATEGORY LISTS :
LONG LISTS II

4:9:1 Method and Procedure

The method and procedure were virtually identical to that employed in Experiment 7, as were the stimulus lists. The only difference lay in the instructions issued to the subjects. Whereas in the previous experiment subjects had been left free to recall the lists in any order they wished, in this case they were told specifically that when presentation ceased they were to recall as much as they could from the end of the list before attempting to recall earlier items. For the blocked condition subjects this meant their first recalling as many terminal blocks as possible, while for the random condition subjects this entailed exhausting their recall of all later list items before proceeding to earlier ones. It was emphasised that this stipulation was crucial to the particular experiment being conducted and was therefore to be obeyed regardless of any other strategy which may appear to be a more 'natural' way of going about the task.

As in the previous experiment, an unexpected final free recall test was administered after the main testing session. For this, subjects were permitted to recall in any order they chose.

Subjects

A further 40 undergraduate students attending the Part I Psychology course at the University of Stirling served as subjects for the experiment. They received a course credit for their participation. None had previously taken part in any memory experiment for the author. Twenty subjects were assigned randomly to the blocked-list condition and 20 to the random condition.

4:9:2 Results

Scoring : Immediate Recall (IR)

As in Experiment 7 the percentage correct scores for each serial position were calculated. These are shown for both blocked and random condition subjects in Figures 4:7 and 4:8 (upper curves). Examination of the function for the random condition (Figure 4:8) reveals that terminal item recall was considerably higher than the equivalent data from Experiment 7. Moreover the recency effect closely resembles that found by Murdock (1962) for 40-item lists in that it extends over 6 or 7 items. These observations strongly suggest that the instructions administered in the present experiment were effective in pre-empting the use of possible alternative strategies. On the other hand the blocked condition now

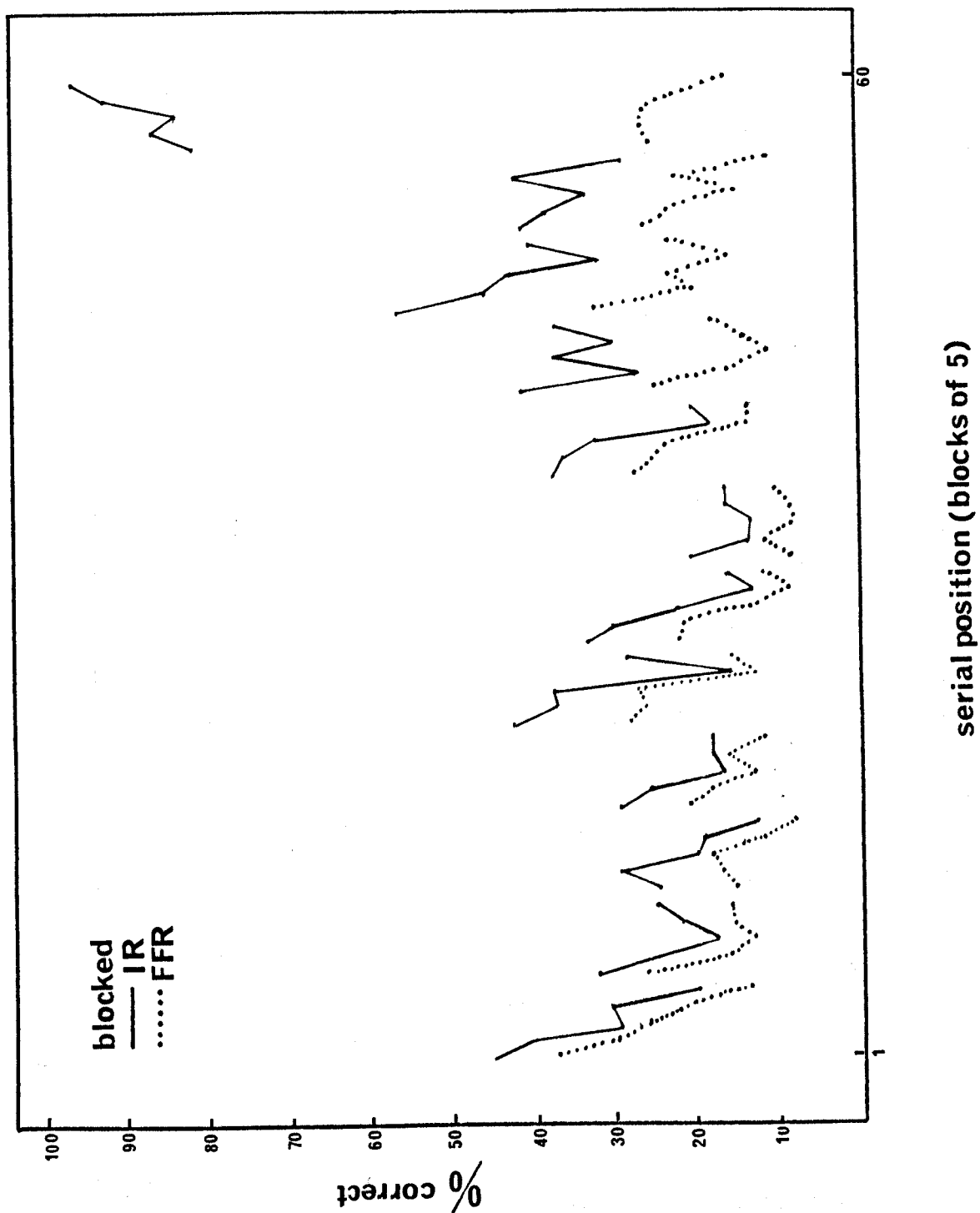


Figure 4:7 Serial position curves for the blocked condition lists under both immediate (IR) and final free recall (FFR).

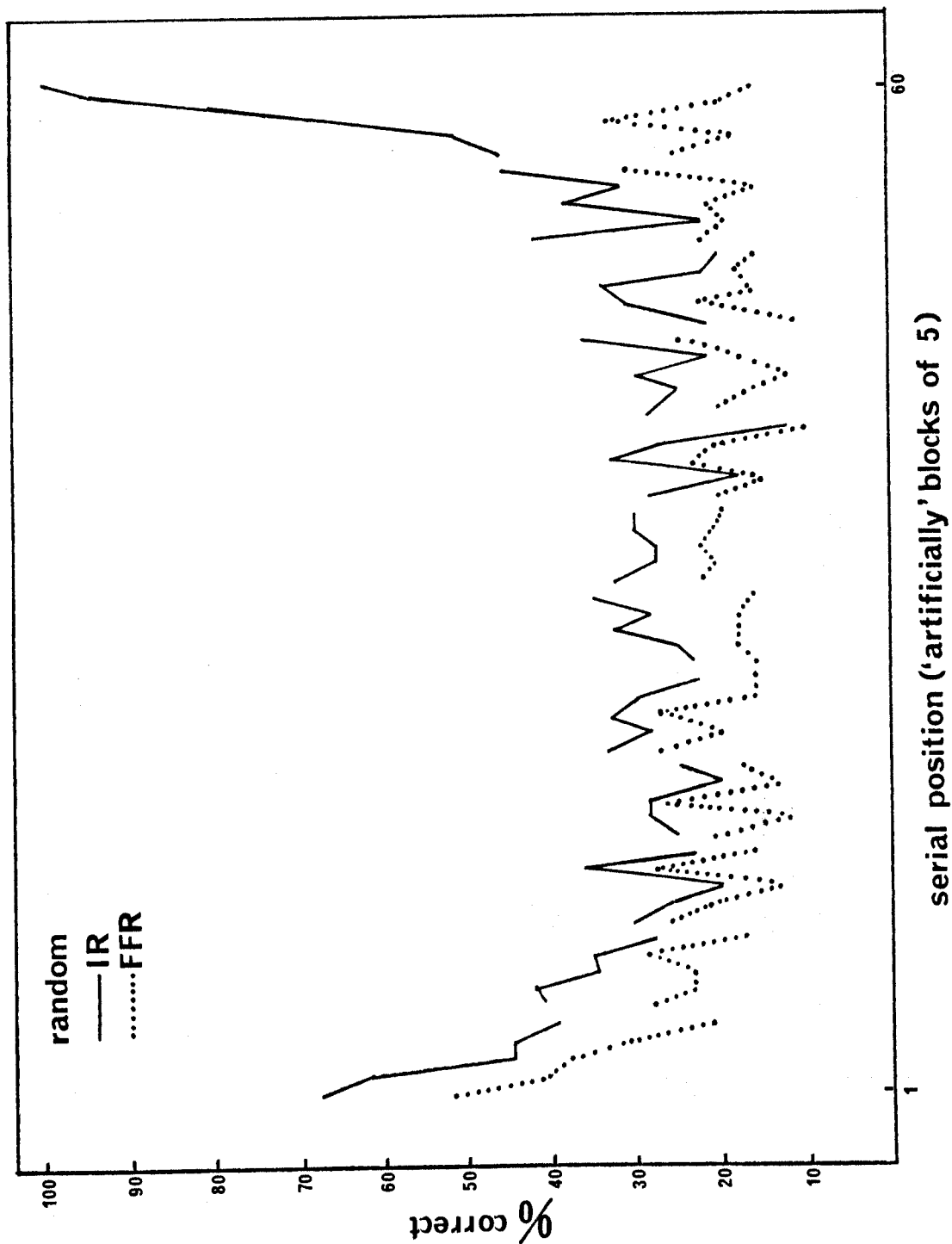


Figure 4:8 Serial position curves for the random condition lists under both immediate (IR) and final free recall (FFR).

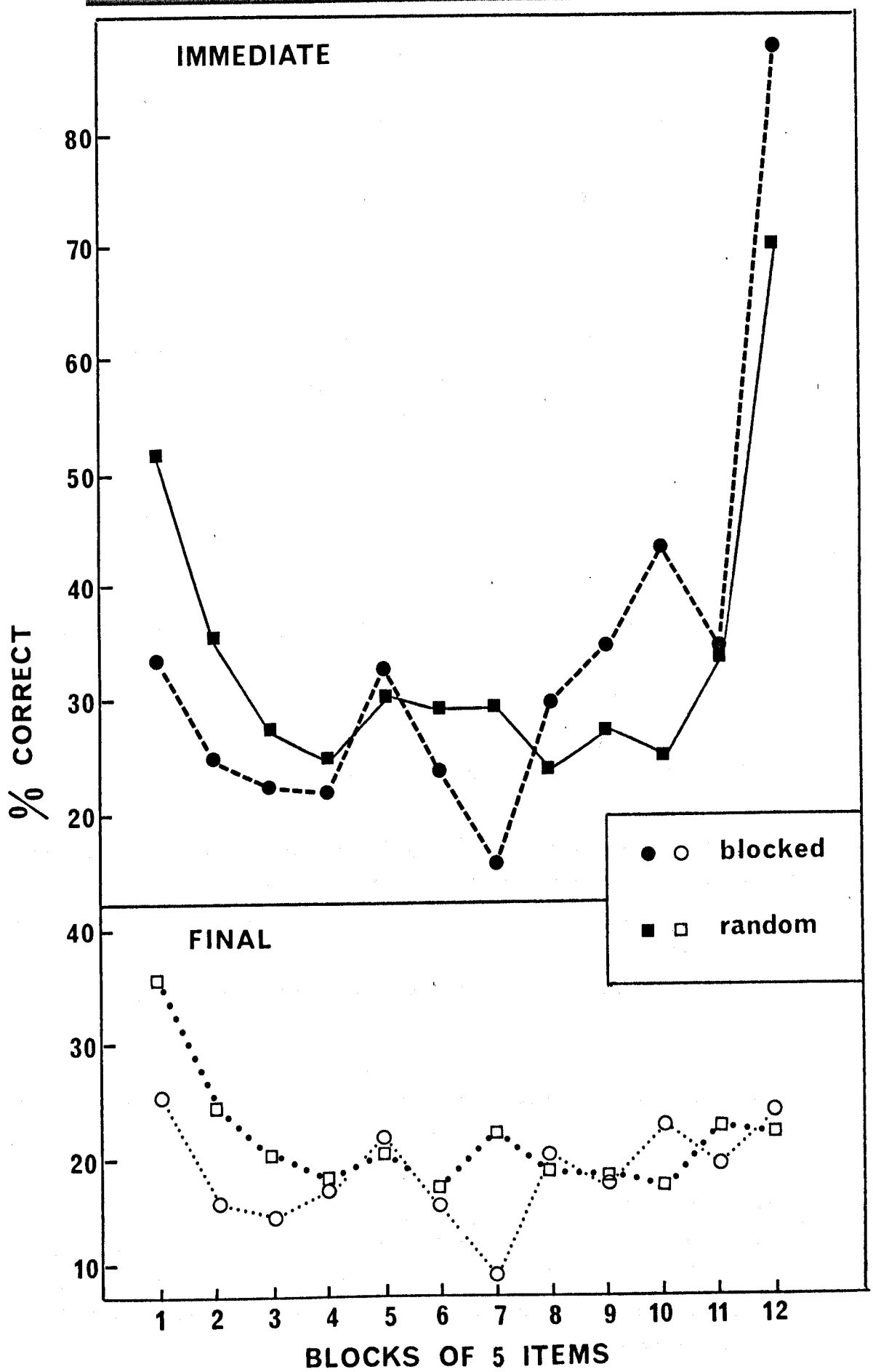


Figure 4:9 Serial position curves for both blocked and random list conditions collapsed over groups of 5 items. Upper panel - immediate recall; lower panel - final recall.

appears to indicate a recency effect for terminal blocks (Figure 4:7). Only the penultimate category appears to deviate from this trend. Once again for a clearer indication of the effect of blocking categories the data were collapsed over groups of 5 items. This is shown by the upper curves of Figure 4:9, and in fact tends to confirm the above observations. For example the random condition recency is confined to the last two groups, while for the blocked condition the recency effect extends over the last 5 groups of items. In addition, Figure 4:9 indicates that blocked is superior to random for later items although the reverse appears to be the case for the early portion of the curve.

Scoring : Final Free Recall (FFR)

As with Experiment 7, reminiscence items were excluded from the main analysis of final free recall. Thus the full serial position data for FFR of those items also recalled in IR is depicted in the lower curves of Figures 4:7 and 4:8. Similarly the collapsed version of these data is contained in Figure 4:9.

Analysis of variance was conducted on the collapsed version of the data for both blocked and random condition subjects under both immediate and delayed recall. This revealed no significant main effect of list format ($F < 1$), although both other main effects of delay ($F(1,38) = 703.05, p < .001$) and serial position ($F(11,418) = 23.67, p < .001$) were highly significant. The interaction of list type x serial position was also significant ($F(11,418) = 5.20, p < .001$) confirming the observation from Figure 4:9, that blocking is superior to random for the later groups while the opposite is true for earlier blocks. Similarly the interaction of delay x serial position was significant ($F(11,418) = 80.24, p < .001$) underlining the usual finding that the recency effect of immediate recall is eliminated under conditions of delay while primacy remains intact although at a lower level. On the other hand the list type x delay interaction was not significant ($F(1,38) = 1.5, p > .05$) indicating that performance under both types of list condition was affected by delay in the same manner. Finally the three way interaction of list type x delay x serial position was highly significant ($F(11,418) = 4.71, p < .001$). Reference to Figure 4:9 assists the interpretation of this effect by showing that the greater recency effect exhibited by the blocked condition subjects in immediate recall is reduced to approximately the same level as the random condition subjects under conditions of final recall.

Category Recall

While the above results appear to demonstrate that recency can occur for groups of semantically related items there are still two possible explanations of the results. On the one hand the effect could be due to the blocked condition subjects recalling more of the terminal categories (and thence more items from the last groups). On the other hand subjects may have recalled roughly the same proportion of categories from the end of the list as from the early and middle portions but somehow recalled a higher proportion of items from the later blocks. In order to determine which of these possibilities was the underlying cause of the effect an analysis of the number of categories recalled by blocked condition subjects was performed. This form of scoring disregards the number of items recalled for each category and merely records the number of categories recalled. The results of this analysis expressed as percentage scores for each category input position are presented in Figure 4:10. For comparison purposes the upper panel presents these data for Experiment 7, while the lower panel gives the equivalent for the present experiment. Several features are immediately apparent from these functions. Firstly it should be noted that the immediate recall curves bear a striking similarity to the function normally obtained for the free recall of unrelated items. This is particularly true for the present experiment (lower panel) where the IR recency effect is more pronounced and generally superior to its primacy equivalent. The IR curve for Experiment 7 while showing a similar trend describes an altogether flatter 'U' shape. Both curves however tend to follow the same outline as their equivalent collapsed scores analyses, thus strongly suggesting that it is category recall which determines the effects obtained. Again this is in keeping with previous work using similar stimuli (eg Tulving and Pearlstone 1966). Finally both experiments show that whatever recency for categories was obtained in immediate recall is eliminated in final recall.

In order to determine the precise nature of the effect of the instructions employed in the present experiment, the raw scores from this category analysis for both experiments were subjected to analysis of variance. As expected the main effects of delay ($F(1,38) = 134.11$, $p < .001$) and serial position ($F(11,418) = 10.53$, $p < .001$) were significant. While the main effect of instructions was not itself significant ($F(1,38) = 3.26$, $p > .05$), the interaction term instructions x serial position was highly significant ($F(11,418) = 3.61$, $p < .001$). Examination of Figure 4:10 confirms that the prime effect of the instructions to recall from the end of the list has been to shift the pattern of superior recall from the primacy portion of the curve in Experiment 7, to the recency portion in Experiment 8, while maintaining

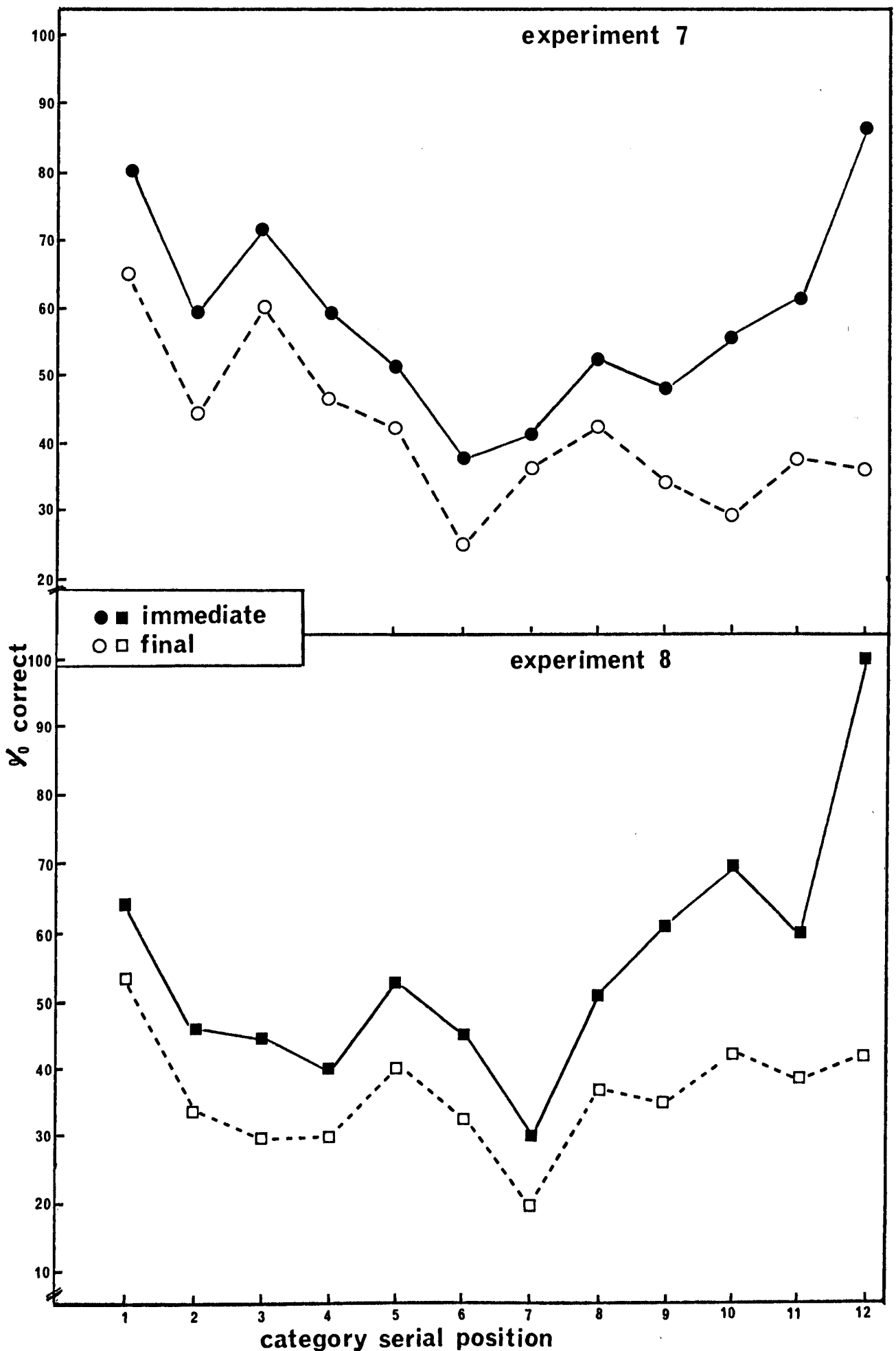


Figure 4:10 Serial position curves for the categories in the blocked condition lists in Experiment 7 (upper panel) and Experiment 8 (lower panel). NB - Analysis merely records category recall, and disregards the number of items recalled per category.

the same overall level of recall. This is in accordance with the output order of recall observed in Experiment 7 where more of the initial categories were produced early during recall than had been anticipated. Of the remaining interactions, delay x serial position was once again significant ($F(11,418) = 21.29, p < .001$), while instructions x delay was not ($F(1,38) < 1$). The three way interaction instructions x delay x serial position also failed to reach significance ($F(11,418) < 1$).

The original aim of Experiments 7 and 8 was to test the hypothesis that recency effects can be demonstrated for units larger than the individual words typically produced in free recall experiments. To this end long lists containing groups of related items were presented to different groups of subjects. For the hypothesis to be supported the recency effect required to be superior for those lists where the related items were grouped together at input. Normal list recency for terminal items was anticipated for the random conditions.

The combined results of Experiments 7 and 8 are of considerable theoretical importance. Firstly they provide a more convincing demonstration of recency for large, distinct groups of items (provided these are blocked during input) than existing evidence on the topic (eg Glanzer 1972). Moreover the weakness of the effect in Experiment 7 and its more striking counterpart obtained under the conditions of Experiment 8 provides greater insight into the nature of the effect and its operation. Likewise the provision of the delayed condition (final free recall) extends this information by furnishing details of the long-term levels of recall. The implications of these findings for the mechanism responsible, together with their bearing on the major theoretical positions, will now be considered.

4:10:1 The Nature of the Recency Effect for Large Units

Three features of the data which would appear to be important in defining the underlying mechanism can be identified. Firstly the effect applies to categories (or category superordinates) rather than all the individual items of which they are composed; secondly the effect is a short-term phenomenon; and thirdly, and extending the preceding observation, the effect is susceptible to output interference.

Evidence for the first observation comes from the category-only analysis and the full serial position data for the blocked list subjects. Thus while the general level of recall appears to be determined by whether or not a particular category is retrieved (Figure 4:10) the actual level achieved for each individual item is governed by the same within-list functions as those noted in Experiments 5 and 6. Thus within the raised level produced by the retrieval of a greater number of terminal categories (Experiment 8), scalloping still obtains (Figure 4:8).

That the recency effect is purely a short-term phenomenon is evident from all of the final free recall data. The clearest picture of this however, unclouded by the individual serial position data, is given by the category-only analysis of Figure 4:10. From this it can be seen that the recency effect for categories is eliminated in delayed recall and

performance falls to roughly the same level as that pertaining to the middle portion of the function.

Finally, it should be noted that the discovery of a recency effect for category blocks does not lead automatically to an overall improvement in the level of recall achieved for lists where the effect is present. This qualification is necessary because of the lack of any significant difference between the random and blocked list conditions in both the experiments reported. Indeed it is also borne out by the failure to find a significant main effect of instructions when comparing the two groups of blocked condition subjects in Experiments 7 and 8. Rather what does appear to happen is that the profile of recall is altered, within the constraint of some retrieval limitation, depending upon the output order adopted. This finding, which is supported by the relevant interaction terms, is important for at least two reasons. In the first place it shows a degree of flexibility in the allocation of response resources within the boundaries governed by the retrieval limitation noted above. Secondly, and more importantly in the present context, it suggests that the mechanism responsible for category recency is affected detrimentally by the act of recalling earlier categories from the list. Superficially at least this finding appears similar to the finding that recency for individual words is eliminated by having to recall earlier list items first (Tulving and Arbuckle 1966).

The question now arises as to whether the recency effect obtained in the present blocked category lists is determined by the same mechanism as that responsible for normal recency for individual items. Certainly there are some striking similarities between the two effects. For example the category recency appears just as susceptible to delay as recency for individual items; the final free recall data from the present experiments shows little or no evidence of recency surviving the imposed delay in much the same way as Glanzer and Cunitz (1966) demonstrated the vulnerability of individual item recency to interpolated activity. Similarly, the category recency appears to be affected adversely by output interference generated by recalling earlier categories first and this again parallels the work on single word stimuli (cf Tulving and Arbuckle 1966).

On the other hand there are certain differences between the two effects which also require to be taken into consideration. To begin with the effect in the blocked category experiments covers a great many more items than is typically the case in normal free recall. In fact the figure is probably of the order of 25 items in Experiment 8. Although at first sight this appears to be at variance with the normal finding it is arguably not appropriate to compare individual items in this way.

After all it is the recall of the categories themselves (i.e. the category superordinates) which determines the recall of the items they subsume. A more meaningful measure therefore is one which only takes account of category recall as any retrieval strategy is likely to have its major effect there. From the category - only analysis of Figure 4:10 it can be seen that the recency effect spans the last 5 categories - a figure in close agreement with recency effects for individual words.

More difficult to explain however is one aspect of the output interference finding. It has already been noted that if later categories are recalled first then recall of earlier categories appears to suffer. Similarly, if the earlier categories are recalled first the category recency effect is impaired. This latter finding, together with the elimination of recency by delay, was interpreted as demonstrating that the mechanism for recency retrieval is extremely vulnerable to interpolated activity of any kind (as is normal recency). If this is indeed the case it is difficult to see why the act of recalling items from any one terminal block apparently does not interfere with the retrieval of other terminal blocks. Perhaps one explanation might be to assume that a retrieval operation on terminal category superordinates is carried out prior to the act of recalling any category exemplars. This however would still appear to leave the problem of maintaining the category labels in some active state while simultaneously retrieving and outputting the items themselves. It is not immediately obvious how this might be achieved without cost to one or other operations, and therefore this must remain a problem for the moment. It should be noted that a somewhat similar finding has been reported by Patterson (1971) in a task which also involved the recall of categorised material. She found that even the insertion of a counting task between each item recalled did not impair the retrieval plan.

That difficulty notwithstanding, there appear to be more similarities between category recency and traditional recency than major differences. On the basis of the evidence so far presented therefore, and in the interests of parsimony, it would seem appropriate to assume that the same underlying mechanism is responsible for both effects. Given that premise, it is necessary to explore whether existing accounts of recency can encompass the new findings.

4:10:2 Theoretical Implications

As noted in the introductory section to Experiments 7 and 8 evidence of recency for large complex units would appear to challenge dichotomous views of short-term memory which equate recency with a limited capacity STS, (Waugh and Norman 1965; Craik 1968; 1971; Glanzer 1972). Quite simply the effect spans too many intervening items for the store to be

able to cope. This is true even if one takes account of the fact that the recency effect applies to the category names rather than the individual items themselves. To elaborate, if the STS is devoted purely to processing the category labels in order that they may be offloaded at the time of recall, it is difficult to see what processing is afforded the items themselves. That such processing of the items must take place is evidenced by the robust long-term nature of the within-group functions.

Also the argument advanced by Glanzer and Razel (1974) to account for such phenomena is difficult to accept for the reasons noted earlier. It will be recalled that their explanation required a mechanism which is severely limited in the number of units it can hold, but virtually unlimited with respect to the number of items these units contain. Given that this mechanism has to process all these items and given that the processing of as few as four irrelevant items disrupts recency (Glanzer, Koppenaal and Nelson 1972) this account would appear to be internally inconsistent.

A somewhat different set of criticisms can be applied to the Atkinson and Shiffrin (1968) buffer model. In the view of these authors, recency reflects the output of a limited-capacity rehearsal buffer, while any item's long-term potential is determined by its length of residence in STS. Earlier it was found that such a model provided a very adequate explanation of the original blocked category experiment (Experiment 5). The present results however offer no such comfort. In particular the extent of the recency effects obtained must be considered as fairly damning to the buffer model. This is simply because too many intervening items are involved. Even an attempt to explain the category recency effect by appealing to the fact that only the category labels themselves are maintained within the rehearsal buffer would appear to be faced with considerable difficulty.

For example if one assumed that the category superordinates are held within the buffer mechanism, then those terminal categories currently resident at the time of recall could, theoretically, give rise to the category recency effect. However, to ensure that each category block possesses the long-term primacy component observed in the data, the initial items within each block would require to be held in STS for long periods. The normal method of ensuring this would be to recirculate them through the rehearsal buffer. Under this scheme therefore, it appears that the buffer is required to engage in a time-sharing exercise and allocate resources to both category labels and selected items. The introduction of this additional complication would seem to place some strain on a limited capacity mechanism, and this in turn would seem likely to reduce the potential level of one or other of the effects. Yet the data from

Experiment 8 show both block primacy and category recency to be substantial. Therefore it is difficult to see how the explanation can account adequately for the results of the present experiments.

The data of Experiments 7 and 8 are explained even less satisfactorily by a levels of processing account (Craik and Lockhart 1972; Craik and Tulving 1975). It has already been pointed out that the framework lacks sufficient precision to predict the within-list primacy effects (at least in a way which is distinguishable from the modal model). This short-coming derives principally from the inability of the approach to differentiate within the semantic processing domain. A slightly different limitation prevents the account from handling adequately the different levels of performance as shown by the serial position data for the categories themselves - in particular the category recency effect.

It will be recalled that the depth of processing explanation of free recall recency assumes that a change of strategy occurs towards the end of a list such that a shallower (phonemic) form of processing is devoted to terminal items. There are several reasons why this is unlikely to have been the case in the present experiments. Firstly, there is the obvious point that the lists were extremely long. It is therefore improbable that subjects were able to anticipate the end of a list - an essential prerequisite if they were to alter processing strategy at the appropriate time. Further, as only four lists were used in the experiment there would be little opportunity for experience of the list length to build up during the session. Moreover the levels account of recency, applied to the present experiments, would imply that terminal categories receive only a shallow (non-semantic) form of processing. However since it is clear that the semantic nature of the material is used to guide both the retrieval of the categories, and the items they contain, this would seem to be somewhat implausible.

In a similar vein, any other interpretation from the model which assumes that those items currently held in conscious awareness (PM) at the time of recall can be output to produce recency is rendered inappropriate by the extent of the recency effects obtained.

Thus far, the results of Experiment 8 have demonstrated two recency phenomena: The traditional effect which spans the terminal items in immediate recall, and a second effect operating in parallel which appears to be contingent upon the provision of distinct groupings within the organisation of the list. Both effects are short-term in duration in that they are not present in the final recall data, although the phrase 'relatively short-term' would seem a more appropriate description of

the category recency effect given that it spans a greater number of intervening events. As there would not appear to be sufficient grounds for assuming that these dual phenomena are the product of different mechanisms, most of the established theories have great difficulty in accounting satisfactorily for the results.

The necessary preconditions for a successful explanation appear to preclude the operation of any fixed capacity mechanism, thus ruling out existing versions of the modal model. While the semantic nature of the material (and the very reasonable assumption that all words within a given category are processed as being related, and belonging to, that category) would seem to obviate any account based on superficial levels of encoding. The most promising basis for a satisfactory account of these recency phenomena therefore would appear to be one which seeks to explain the findings via the operation of some retrieval strategy, assuming that this can be applied either to recent individual items, or to recent groups of items which appear 'distinct' at the time of recall. This last prerequisite, which assumes that the time of testing is crucial in defining the units for recency, easily explains the lack of any recency effect for terminal items or terminal categories under the conditions of final recall. Quite simply neither of these dimensions is relevant to recency retrieval when recall is tested at the end of the session.

This therefore immediately reopens consideration of the final class of theories developed exclusively to handle recency phenomena. In this context both the relative temporal discrimination hypothesis proposed by Bjork and Whitten (1974) and the ordinal retrieval strategy model advanced by Baddeley and Hitch (1977) are capable of handling the category recency effects obtained. This is the case because each of these models explicitly states that units larger than the individual word are appropriate to such a retrieval strategy, provided that they are in some way cohesive units. As currently formulated however, both models are less well-equipped to explain the normal terminal item recency effect obtained in the experiments. For the Bjork and Whitten (1974) account, explanation of this result would appear to require a relaxation of the veto on cumulative rehearsal. On the other hand, Baddeley and Hitch (1977) require to lift their ban on recency for related material, although some support for their current position does come from Experiment 7. Craik and Jacoby's (1975) multiple model offers perhaps a more complete account given that it can appeal to more than one process. For example, recency for individual items is explained by those items still being within PM at the time of recall, while the category recency effect could either

reflect the backward scanning mechanism or aspects of a reconstructive process. Although at no time during their statement of the model do Craik and Jacoby (1975) explicitly make the point that recency can occur for units larger than individual words, the fact that they refer to such findings elsewhere in the text suggests that they view the model as being capable of handling such effects.

Finally it should be noted that the view of recency advanced above leads to a further prediction concerning the present data. It was suggested that neither recency for terminal items nor terminal categories was obtained under conditions of final recall because these do not constitute appropriate units for recency retrieval at the end of the session. However one dimension which might well be appropriate in this context would be that of input list. Furthermore, the most general case of this sort of model would predict that list recency should be a feature of both blocked and random condition lists. In both cases lists can be viewed as having been processed as cohesive units, regardless of the differences in their presentation formats. With this in mind therefore one final analysis which examined recall as a function of input list under both immediate and final recall was conducted on the data from Experiment 8. The results of this are depicted in Figure 4:11. Of particular relevance to the present discussion are the upper curves which represent final recall expressed as a percentage of immediate recall for each list condition. These data clearly show that more is retained from later lists than earlier ones, and that this is true for both blocked and random lists. Thus the view of recency advanced here would appear to be supported.

One note of caution should be sounded. The experiment from which these curves were obtained only involved the presentation of four lists. This may be considered inadequate for a complete mapping of the extent of any such recency effect. The following chapter therefore will attempt to examine this effect in greater detail before firm conclusions regarding its generality and nature are drawn.

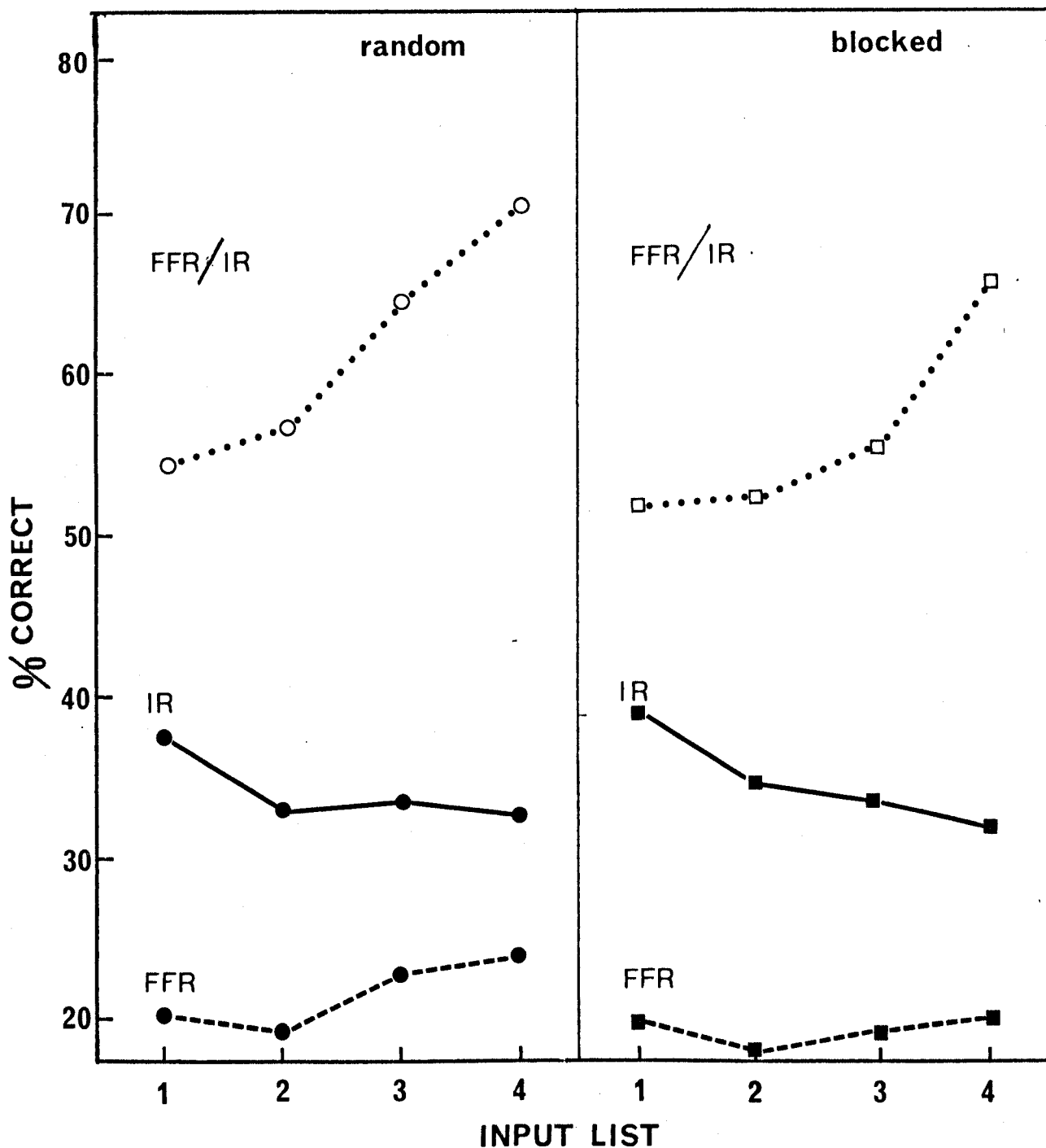


Figure 4:11 Percentage of items correctly recalled in Experiment 8 as a function of input list under conditions of immediate (IR) and final free recall (FFR). Left panel - random lists; right panel - blocked lists; uppermost curves represent FFR expressed as a percentage of IR.

The findings of the long lists experiments just described both confirm and extend the results of the previous two experiments using categorised material. The main features of the results can be summarised as follows

(i) There appears to be a retrieval limitation which applies to experiments employing large numbers of categories within any one list (regardless of presentation format). This relates to the recall of the categories themselves and seems likely to be a problem of accessibility (cf Tulving and Pearlstone 1966).

(ii) Recency for units larger than individual words can be demonstrated convincingly using a blocked-category format, provided that attention is paid to two crucial factors. These are (a) the output order during recall, and (b) appropriate measurement of the units in question. With regard to the first of these, the results exhibit a striking resemblance to the normal recency effect for individual words in that the effect is reduced if subjects do not output terminal categories early in recall (cf Tulving and Arbuckle 1966). On the second point, the effect is very clearly seen if the data are analysed only in terms of whether or not each category was recalled.

(iii) The susceptibility of the category recency effect to both output interference, and delayed (final) recall highlight the transient nature of the phenomenon. However given that this effect spans considerably more intervening items than traditional recency, previously accepted views on short- versus long-term processes seem inappropriate. This point is reinforced by the tentative evidence of a list recency effect found in final free recall. It was noted that the potential importance of such a finding demands replication.

The use of categorised material in different formats in free recall tasks, and the focus given to the serial position data this generates, has had several consequences. Firstly, it has facilitated a link between the research into organisation in memory and other work which has concentrated on an information-flow approach. Secondly, the findings generated by the paradigm, which revealed some radical departures from the typical free recall profile, have led to a critical evaluation of the major theoretical positions under consideration. In this context, two particular effects can be singled out as being of crucial significance :

(i) The within-list primacy effect contingent upon the beginning of a group of related items, and

(ii) A recency effect for the category blocks themselves which is exhibited when the lists are sufficiently long and terminal categories are output first.

A third effect, suggestive of list recency was also discovered but the full implications of such a result must await further experimentation.

Early work with the paradigm (Experiments 5 and 6) which revealed the first of these phenomena seemed most easily explained by the modal model. In particular, the version proposed by Atkinson and Shiffrin (1968) was considered the most adequate account. Their explicit use of control processes to direct the flow of incoming stimuli through a rehearsal buffer, and the fact that such processes are likely to be responsive to the known facts concerning the processing of related material (Rundus 1971) appeared to offer the best fit to the data. Evaluation of the levels of processing theory (Craik and Lockhart 1972; Craik and Tulving 1975) in this context showed the model to be unsatisfactory. In particular it seemed to be insufficiently precise as regards specifying different possible levels within the semantic processing domain. In order to surmount this difficulty it could be argued that the model could still appeal to differential rehearsal to account for the within-list primacy effects. In doing so, however, the model is rendered virtually indistinguishable from a dichotomous approach.

The discovery of the second effect (Experiments 7 and 8) altered this picture substantially. The finding of a recency effect for category blocks and the suggestive evidence of a similar finding for lists in final free recall negates any explanation based on the operation of a

limited-capacity short-term store. The modal model therefore is not supported by such data. On the other hand, a levels approach is equally embarrassed by these findings because (a) the units which make up recency cannot still be within the span of conscious awareness, and (b) must be assumed to have received semantic processing. Explanations which focus on the operation of a retrieval strategy however faces no such difficulties in accounting for the data. Of these the Craik and Jacoby (1975) model appeared to fit the data well, although it is probably true to say that the theories of Bjork and Whitten (1974) and Baddeley and Hitch (1977) would not require substantial modifications in order to handle all the effects.

The essential flexibility of retrieval strategy accounts derives from the fact that they are neither constrained by the size of the possible units which make up recency effects, nor by a rigid distinction between what is short- and what is long-term. In this context it is instructive to note that such a distinction appears to have outlived its usefulness, at least as far as recency is concerned. Certainly the category recency effect is short-term in the sense that it doesn't appear under conditions of final recall. The point however would appear to be, that at such a time, the terminal categories within any one list no longer constitute an appropriate dimension for the recency strategy. At such a time, the lists themselves would appear to become the most relevant units, although further work on this appears to be indicated to establish this possibility.

CHAPTER 5

FREE AND FINAL FREE RECALL OF CATEGORISED MATERIAL

- 5 : 1 PREFACE
- 5 : 2 INTRODUCTION
- 5 : 3 EXPERIMENT 9 : FREE AND FINAL FREE RECALL OF
SEMANTIC MATERIAL 1
- 5 : 4 EXPERIMENT 10 : FREE AND FINAL FREE RECALL OF
SEMANTIC MATERIAL 2
- 5 : 5 GENERAL DISCUSSION OF EXPERIMENTS 9 and 10
- 5 : 6 GENERAL SUMMARY OF CHAPTER 5

The final set of experiments to be reported seeks to investigate further two particular recency effects using the final free recall (FFR) paradigm (Craik 1970). The first of these concerns the long-term retention of terminal items in a list and stems from the original Craik study which demonstrated that those items recalled best in immediate recall are actually recalled worst in final recall. Attempts will be made to examine critically this 'negative recency' effect (Craik 1970). The second major reason for conducting the following experiments was to evaluate more thoroughly the list-recency phenomenon observed in the last chapter. As before, the categorised material so frequently used in the study of the organisation of memory will be utilised. The methods of analysis however will be principally those to have emerged from the mainstream theoretical investigations of short-term memory tasks.

Concern in this chapter will be devoted to two main issues :
Recency for individual items and recency for larger units, where both are examined as a function of the semantic nature of the material.

5:2:1 Recency for Individual Items

5:2:1:1 Positive and Negative Recency after Delay

The immediate free recall of word lists exhibits a consistent bow-shaped serial position function. However when recall is delayed by the interpolation of some additional task which has to be performed following presentation the superior recall of terminal items is eliminated (Glanzer and Cunitz 1966). Under these conditions performance on later items drops typically to the same asymptotic level attained by mid-list items. There are however two principal exceptions to this rule.

(i) Positive Recency after Delay: These are cases where recency superiority is reduced but not eliminated totally (Glanzer, Koppenaal and Nelson 1972). This has been referred to in Chapter 3, and the most common explanation is that it represents the product of an insufficiently demanding distractor activity. According to this argument an interpolated task which is either very simple or is slow-paced is unlikely to occupy the subject's attention fully, and therefore the possibility remains that some additional processing of the memory material occurred.

(ii) Negative Recency after Delay: The second case is where the delayed recall of recency items actually falls below the level attained by mid-list items, such that those items recalled best in immediate recall are retained worst following a delay. This phenomenon has been termed 'negative recency' and was first observed by Craik (1970).

5:2:1:2 Delayed versus Final Free Recall

Although the negative recency finding has been observed in the conventional delay paradigm (Gardiner Thompson and Maskarinec 1974) the original report of its occurrence and most of the subsequent work on the effect involves a procedure known as final free recall (Craik 1970). The main difference between this and the conventional delay task can be summarised as follows. In the conventional paradigm, list presentation is followed immediately by an interpolated task - typically the Brown-Peterson distractor of counting backwards in three's for a prescribed period of seconds. Comparisons are then made with performance on control lists where presentation was followed by an immediate recall test.

In the final free recall paradigm, the subject is presented with several lists for immediate recall (resembling the control lists in the conventional situation). However following these an unexpected recall test is administered during which the subject is required to produce as many items as possible from all previous lists. Two principal advantages are claimed for this FFR method. Firstly, as no distractor activity is required, the subject is never engaged in processing any 'irrelevant' material which is extraneous to the lists under study. Secondly, it is possible to examine directly which items recalled during immediate recall are reproduced subsequently under final recall. By definition however this introduces one further difference, namely a second presentation of certain items brought about by their being output during immediate recall.

5:2:1:3 Early Interpretations of Negative Recency

Original views on the effect (Craik 1970; Craik Gardiner and Watkins 1970) assumed that it contributed further evidence to the dichotomous position represented by such models as Waugh and Norman (1965) and Atkinson and Shiffrin (1968), although the result was always compatible with a dual retrieval process theory (e.g. Tulving 1968). At a later stage Craik modified his position to explain the effect via the levels of processing framework (Craik and Lockhart 1972), although as others have noted this does not necessarily represent a significant departure (e.g. Postman 1975)

5:2:1:4 Further Experiments with the FFR Paradigm

Subsequent work with the final free recall technique has followed a similar line of reasoning to that of Craik's by experimentally manipulating the nature of the processing afforded terminal items (e.g. Mazuryk 1974; Shallice 1975). The experiment by Mazuryk clearly illustrates this approach. His subjects were presented visually with 14-item lists where the first 10 items were typed in lower case, and the last 4 in block capitals. One of three tone cues accompanied presentation of the 10th item, and signalled the method of encoding to be adopted for the last 4 items. The three processing modes were (a) silent learning i.e. the same as that for the first 10 items, (b) overt rehearsal, and (c) the generation of verbal associates. The results indicated that both silent and overt rehearsal produced superior immediate recall performance, while the generate-associate condition produced higher final recall. In particular, the FFR function for this third condition lay above the asymptotic level of the curve - positive recency - while the other conditions showed performance tailing off towards the end of the list - the typical negative recency finding. On the basis of this evidence and that of a similar experiment

using sub-span lists (Mazuryk and Lockhart 1974), the author concluded that the levels of processing approach was supported. That is to say that negative recency in FFR is the result of qualitatively poorer processing which is normally devoted to terminal items. When semantic encoding is devoted to these items, positive recency is obtained, although there may be some cost to immediate recall. It should be noted that this interpretation represents a departure from earlier explanations of recency survival after delay which were based on insufficiently demanding distractor activities.

The experiment by Shallice (1975) is essentially similar to the silent condition of Mazuryk's (1974) study. In his experiment Shallice compared the free recall of a control group instructed merely to output terminal items first in immediate recall with that of an experimental group who were 'cued in' to the last five items and encouraged to rehearse them in readiness for recall. The results showed superior IR recency for the experimental group with the last five items exhibiting a marked scalloping similar to the blocked-category experiments of the previous chapter. As in the appropriate comparison condition in Mazuryk's (1974) study, this superiority was not maintained in final recall although evidence of the scalloped nature of the function was preserved.

The results of the experiments cited above make several points. Firstly, they show the value of instruction, and/or the provision of cues, in improving the immediate recall of terminal items. In this respect they reflect the advantage of providing 'recoding points' similar to the situation in the blocked-category experiments of the previous chapter. Secondly, they imply that this benefit may not necessarily be carried over into final recall unless accompanied by a more durable (semantic) form of encoding (implied by the data of Shallice 1975; and confirmed by the results of Mazuryk 1974). While these findings are important, it can be argued that the procedure adopted in the above experiments introduces its own complications. Two particular comments are appropriate in this context.

(i) The Introduction of 'Irrelevant Material' : The condition chosen by Mazuryk (1974) to represent a form of semantic processing was that of generating verbal associations to the critical last four items. This method therefore introduces the overt production of 'extraneous' material, and may well have contributed to the lower immediate recall for this condition. When one considers that one advantage of the FFR situation is deemed to be the avoidance of processing non-list material (by dispensing with distractor activities) this would appear, partly, to defeat the object of the exercise.

. (ii) Shortcomings due to the 'Cued Recoding Points' : More importantly perhaps is the fact that the method involves a highly artificial break during list presentation, at which point processing must begin anew. That this has a dramatic effect is evidenced by the sharp discontinuities in the serial position functions. While similar functions were obtained in the experiments of the last chapter, these were deemed a consequence of a 'natural' strategy adopted by the subject in response to organisational changes in the list material. In contrast, the studies by Mazuryk (1974) and Shallice (1975) show the effects of inducing subjects to encode certain items in a particular way. Given these instructions it is therefore hardly surprising that their results show significant departures from the strategy normally adopted for processing terminal items in free recall. This in turn renders the experiments incapable of addressing certain key questions regarding typical free recall. For example, what is the 'normal' immediate recall function for semantically-linked material (in particular the recency component), and further, what is the precise nature of the long-term retention function for such lists? Phrased in this way the question is subtly different.

5:2:1:5 Recency and Semantically-Related Material

Research on the topic of whether recency effects occur for semantically-processed material has traditionally posed the question the other way round : That is to say, can any semantic effects be detected within the short-term component (and by implication, the recency effect for dichotomous views)? Thus early work was concerned with possible coding differences as a means of further differentiating the two hypothetical memory systems STS and LTM. For example, based on early work by Conrad (1964) and Wickelgren (1965) which showed considerable disruptive effects of acoustic confusions in STM tasks, Baddeley (1966a; 1966b) demonstrated that acoustic similarity affected short-term recall, while the long-term component was susceptible only to forms of semantic similarity. Subsequent work however has tended to blur this distinction, and suggests that while such an account might hold true for a number of cases, it is likely to be an oversimplification. Thus Shulman (1970; 1971) claims evidence of semantic effects in the short-term component in a task where lists were followed by homonym, synonym or identical probe items. Scrutiny of the data from Shulman's (1970) study reveals that while probing with identical items produces a level of recency which is higher overall than probing with synonyms (the semantic condition), the level of recency in the latter case is still substantial, and takes the traditional form. There is then

suggestive evidence that recency effects and semantic relationships amongst the items, are not mutually exclusive occurrences, as was at first suspected. The situation however is still far from equivocal, as Glanzer, Koppenaal and Nelson (1972) failed to find any differential effects on recency as a function of phonemically or semantically similar distractor material - both were equally disruptive suggesting that neither code is appropriate.

Another approach is to repeat the line of reasoning which underlay much of Chapter 4: namely that one way of tackling some of the questions of semantic processing is to employ categorised material. The rationale behind the approach only requires the one fairly reasonable assumption that subjects will process a string of items drawn from the same taxonomic class as being semantically linked - especially when they are aware that recall is required, and any inter-item associations are likely to assist. Under such circumstances subjects are still free to engage in any processing pattern they wish, but unlike lists of unrelated items, this is conducted against a background of an established semantic relationship. With this in mind therefore, a further clue to the question surrounding recency for semantically-processed material is provided by Experiment 5 in Chapter 4. It will be recalled that the aim of the study was to determine the nature of the serial position function for categorised lists containing different numbers and types of category block. However, in the basic control condition, each list contained items drawn from only one category. Under these circumstances the typical bow-shaped curve was observed, exhibiting both primacy and recency. Unfortunately for the question being posed here, the same condition was not included in the equivalent delay study (Experiment 6). Therefore although the immediate recall curve for semantic material bears a striking resemblance to that obtained for unrelated material, it is not possible to evaluate the long-term retention of individual serial positions. The identification of this gap in the existing evidence therefore provides one reason for conducting the experiments to be reported here.

Furthermore by returning to the manipulation of categorised material in standard free recall, questions regarding semantic processing and long-term retention can be examined without risking the problems in designs such as that of Mazurk (1974).

5:2:1:6 Theoretical Predictions

The rationale behind the experiments to be reported is therefore straightforward. Under one condition each list can be made up exclusively of words drawn from a single conceptual category (each list is homogeneous).

Although the subject is still free to adopt any rehearsal/processing pattern he wishes for such lists, it can be assumed that this is conducted against the background of, and in addition to, processing the items as being semantically related. In contrast, control conditions can be included where (a) each list contains a single exemplar of many different categories (the mixed condition), and (b) where all items are totally unrelated as in typical free recall. In these latter two conditions only the idiosyncratic processing of the subject can establish any deep associations between the items for immediate recall, there being no objective relationship present in the list material itself. In final recall however, the same objective retrieval cues could be made available in the homogeneous condition as in the mixed condition, provided that the same categories were used and list length was equated with the number of lists employed.

(i) Levels of Processing : For homogeneous condition lists, and given the assumptions concerning encoding noted above, a levels approach would be forced to assume that all the items were processed semantically (at least according to one fairly simplistic definition of semantic encoding). This implies that they would be better recalled than either of the two control conditions, especially over the pre-recency portion where the establishment of a more 'elaborate' relationship is possible (Craik and Tulving 1975) and especially in the long term because of this. However it must be admitted that certain difficulties - now familiar - are encountered with regard to specific prediction of the serial position effects, and in particular for recency portions. On the one hand Craik and Lockhart (1972) stipulate that free recall recency is most likely to reflect the very shallow (probably phonemic) encoding afforded terminal items. It could be argued that this is unreasonable in the homogenous list condition, where to do so would be to ignore a more meaningful relationship present amongst the items. On the other hand, the model admits that mere maintenance rehearsal can theoretically take place within any one level. Although the possibility of this occurring within the semantic domain is not entertained further, it could conceivably lead to a prediction of normal IR recency for homogeneous lists. The problem is that the model is insufficiently clear to enable a decision to be made concerning these options; i.e. whether subjects are likely to opt to encode semantically-related material at only a phonemic level because this maximises immediate recall, or whether they will maintain these items at a deeper level. Unfortunately such a decision is important as it has implications for the long-term retention of the items i.e. whether the function will be characterised by negative recency or by a stable asymptote. Indeed it is

almost as if the delayed recall function requires to be examined, in order to determine - post hoc - what processing was carried out. Clearly some of these difficulties might be overcome if there were indications that the immediate recall of semantically-related material was characterised by a relatively flat serial position function, indicating a fairly uniform depth of encoding. However, the data from Experiment 5 (ConditionA) do not suggest that this is likely to be the case.

(ii) The Modal Model : No such problems are encountered with the versions of the modal model, which would predict typical immediate free recall functions for all list conditions. Further, the early portion of the function for homogeneous conditions would be superior to that of the controls as the principal benefit of such material would accrue to the long-term component. Long-term recall of terminal items for all list conditions would be likely to be characterised by the negative recency finding owing to the fewer rehearsals afforded terminal items during acquisition (Atkinson and Shiffrin 1968). Indeed the rehearsal data of Rundus (1971) are fairly explicit on this point. (While other experiments appear to challenge the relationship between the number of rehearsals and long-term retention (e.g. Craik and Watkins 1973; Woodward, Bjork and Jongeward 1973) it should be noted that these studies - unlike Rundus - (i) do not leave subjects free to engage in their normal free recall strategy of selecting which items to rehearse together and (ii) do not exhibit conventional free recall functions as a result. To this extent therefore they themselves could be challenged as having only indirect bearing on free recall).

(iii) Alternative Accounts : Finally turning to theories which place emphasis on aspects of retrieval, especially with regard to recency items, it seems to be the case that certain of the recency-only models considered are not particularly appropriate for application to the immediate recall of homogeneous lists. Thus Baddeley (1976) and Baddeley and Hitch (1977) do not anticipate an ordinal strategy of recency retrieval where semantic relationships amongst the items are involved. Bjork and Whitten (1974) on the other hand dictate no cumulative rehearsal as a precondition for recency, which virtually restricts the model to long-term findings only. It should be noted however that any simple ordinal/temporal discrimination strategy, unfettered by the constraints noted, could predict recency for immediate recall of lists regardless of the nature of the items. The Craik and Jacoby (1975) model falls into this latter category. With regard to final recall performance however none of these models would anticipate recency for individual list items, as the appropriate dimension for such a retrieval strategy has shifted to larger and more complex units.

This leads to the second reason for conducting the experiments below.

5:2:2 Recency for Units larger than Individual Words

Up until now attention has focussed on the recall of individual terminal items, as a function of how they are processed, and how in particular this is connected with how they survive periods of intervening activity. The evidence presented in Chapter 4, together with the recent findings in the literature, indicate another class of recency effect which is of potentially greater significance : Namely that occurring for large groups of items.

5:2:2:1 Recency for Unrelated Material

One indication of the above effect comes from the studies by Bjork and Whitten (1972; 1974). The procedure in their experiments required subjects to process pairs of items with periods of interpolated distractor activity occurring between each pair. Under such circumstances, recency effects were obtained for the pair groups. More dramatically, however, when the results of a final free recall test was scored as a function of input list (as opposed to items) an apparent recency effect was obtained for the lists themselves. Such a finding had previously been noted by Murdock (1972) although it is somewhat surprising that despite the vast literature in the area, experiments have typically not been analysed for such an effect. When such effects have been obtained however, usually very few lists have been involved - only four in the Bjork and Whitten (1974) experiment. It is not clear therefore whether this can be viewed as substantial proof.

5:2:2:2 Recency for Semantically Related Material

Two effects of a similar nature to those noted above emerged from the experiments in Chapter 4. The first of these - the category-block effect - showed recency spanning terminal groups of related items, where these could be described as complex, but distinct, units. The second result, which was presented in a more tentative fashion, showed an apparent list recency effect, similar to those described by Murdock (1972) and Bjork and Whitten (1974). Once again however only four lists were involved, and therefore the mapping of the effect could be considered incomplete. Furthermore, it would now appear necessary to tease out the possible differences between related and unrelated groups of items in this context. Clearly a more definitive experimental situation is required to compare directly possible recency effects for lists possessing distinct semantic markers, with those which do not contain the same objective cues but were nevertheless processed as coherent units for the purposes of immediate recall.

(i) Levels of Processing : As noted before this account handles recency phenomena by recourse to a shallow maintenance encoding mechanism capable of holding items within the span of attention in some relatively raw state. Such an explanation is not appropriate to the effects anticipated in the proposed experiments on the basis of the above evidence for two fairly obvious reasons : (a) the items (or units) comprising the effects noted can be assumed to have passed from conscious awareness long before the time of recall, and (b) the semantic nature of the encoding operations performed rules out any form of superficial processing. The theory does state that long-term recall will be a function of the depth (Craik and Lockhart 1972) or degree of elaboration encoding (Craik and Tulving 1975) devoted to the stimulus items. However, as considerations of retrieval are largely ignored, it is again difficult to arrive at a prediction of how this might be characterised with respect to any serial position analysis, except perhaps to say that all items processed to the same basic degree should be retained equally well.

(ii) The Modal Model : This class of theory could not reasonably predict a recency effect for lists any more than it could cope with the category recency effect noted previously. Both the size of the units involved, and the time scale over which the effects operate preclude any explanation based on a limited-capacity short-term mechanism. This leads to the final class of recency models developed.

(iii) Retrieval Strategy Accounts : For reasons stated previously this general class of theories is in a better position to predict and explain the findings under consideration. Both the Bjork and Whitten (1974) account and the Baddeley and Hitch (1977) model permit the operation of a retrieval strategy which can be applied, at the time of recall (whether expected or not), to terminal units. Under this scheme, consideration of what is an appropriate unit is defined in a relative sense. Thus the individual items which make up the terminal portion of any one list are not appropriate under conditions of final recall, as too many other such items have been processed in the interval, thus blurring the salience of this dimension at the time of retrieval. The lists themselves however do constitute an appropriate unit of organisation at the final recall stage, and list recency would presumably therefore be a prediction derivable from such models. Similarly, the Craik and Jacoby (1975) formulation could predict such findings on the basis of the backward scan or reconstructive processes; output from the primary memory mechanism being excluded from consideration.

In this context, it is instructive to note that these various accounts do not appear to differentiate between lists containing semantically-related material and lists containing unrelated items. Both the Bjork and Whitten (1974) and the Baddeley and Hitch (1977) models merely assume that each of the units requires to be processed in some coherent fashion, and that they require to be distinct from one another along some particular dimension. From this it is not clear whether the homogeneous condition lists would be predicted as being 'more distinct' than lists containing unrelated items or not. However as both models appear to stress the relative temporal/ordinal arrangement of the units at recall, it is possible that they would not predict any special differences between these two conditions noted. After all, the lists (regardless of the material they contain) can be viewed as being arranged along the same temporal axis, and they were processed, each in turn, as cohesive units for immediate recall.

In slight contrast the Craik and Jacoby (1975) theory might be assumed to include some advantage for homogeneous lists given that the reconstructive process postulated may be likely to operate more efficiently in the presence of an objective semantic retrieval cue.

5:2:3 Summary

The following experiments were designed in order to evaluate (i) certain features of the negative recency effect in a setting unconfounded by procedural variations during presentation, and (ii) perhaps more importantly, to substantiate the list recency effect described in the last chapter which was considered to be in need of replication and extension.

On the basis of the foregoing review, 3 particular types of list condition were considered appropriate to meet these ends. The first - referred to as the homogeneous condition - is where all the items within any one list are drawn from the same conceptual category. The second - the mixed condition - used the same pool of words but now each list contains only one exemplar of each of the categories in use. In the final condition all lists are made up of totally unrelated items. One potentially important feature of this design is the different appropriateness of the semantic cue in the immediate and final recall of homogeneous and mixed list conditions.

5:3:1

Method

Stimulus Material and List Construction

Three basic sets of lists were constructed according to the following rules with 12 lists in each set and 12 items in each list. For the first set - the homogeneous condition - the Battig and Montague (1969) category norms were used to provide 12 exemplars of each of 12 selected categories. The categories were chosen to be as distinctly different as possible (for example avoiding the selection of both male names and female names to represent 2 categories). These items were then compiled into lists such that each list contained all the items from one category. For the second set - the mixed condition - these same items were used but this time each list was constrained to contain one item from each of the 12 categories. These were further arranged such that each category was dispersed across all serial positions. The final set of 12 lists - the control condition - was made up of unrelated words drawn from Thorndike - Lorge (1944).

While these formed the basic pool of master lists, each subject received a fresh randomisation of the material subject to the constraints of the condition being tested.

Design and Procedure

A between subjects design was employed where subjects were only tested under one of the three types of list condition.

At the beginning of the testing session the nature of the free recall task was outlined. For subjects undergoing the homogeneous and mixed category conditions the list construction was described in full until understanding was complete. No practice lists were administered as it was considered undesirable to expose subjects to extra categories in addition to those contained in the main experiment. (Further, this would have resulted in different numbers of additional categories depending upon which list condition was being experienced).

Lists were read out to the subject at a rate of 1 word per second timed by an electronic device which flashed a light within the Experimenter's field of view. Following presentation of each list subjects were permitted 2 minutes to write their recall on a response booklet provided. A fresh page was used for each list. After recall of the last list had been completed the response booklet was collected and the subject was given a fresh piece of paper. At this point subjects received instructions for the unexpected final recall during which they had to produce as many words as they could from the entire previous session.

All subjects were tested individually, and prior to leaving the experimental room they were asked not to discuss any details of the experiment with any colleagues.

Subjects

A total of 60 undergraduate students from the Part 1 Psychology course at the University of Stirling served as subjects in the experiment. All received a course credit for their participation. None had previously taken part in any memory experiment for the author. They were assigned randomly in groups of 20 to the three conditions of list construction.

5:3:2 Results

Individual items - Immediate Recall Serial Position Data

The number of words correctly recalled was calculated for each group of subjects i.e. each list condition. These data expressed as percentages are shown in Figure 5:1 a. The functions thus obtained display the familiar bowed shape typical of immediate free recall although there are differences in the levels attained for each list condition.

Individual items - Final Recall Serial Position Data

For delayed recall the usual procedure was adopted (after Craik 1970) whereby only those words recalled in the immediate test were scored. The results of this analysis, again expressed as percentage scores are depicted in Figure 5:1 b. It will be noted that there is no evidence of a negative recency effect. The function for the control condition is essentially flat after primacy and closely resembles recall following a period of interpolated activity (cf Glanzer and Cunitz 1966). Final recall for both the category conditions on the other hand appears to display a small positive recency effect spanning the last four items, and this is roughly equivalent in both conditions. In addition this effect seems to be essentially flat, and in no way resembles the shape of immediate recall for the two conditions.

A three factor analysis of variance ($3 \times 2 \times 12$) was conducted on the raw data. List condition was treated as a between subjects variable, while delay and serial position were within subjects comparisons. This revealed that all main effects were highly significant, the respective F ratios being as follows : For list condition, ($F(2,57) = 29.94, p < .001$); delay, ($F(1,57) = 1348.56, p < .001$); and serial position, ($F(11,627) = 63.66, p < .001$). Of the interactions the list condition \times delay term revealed that the different levels of final recall obtained with the three types of input list were significant, ($F(2,57) = 3.52, p < .05$). Similarly the

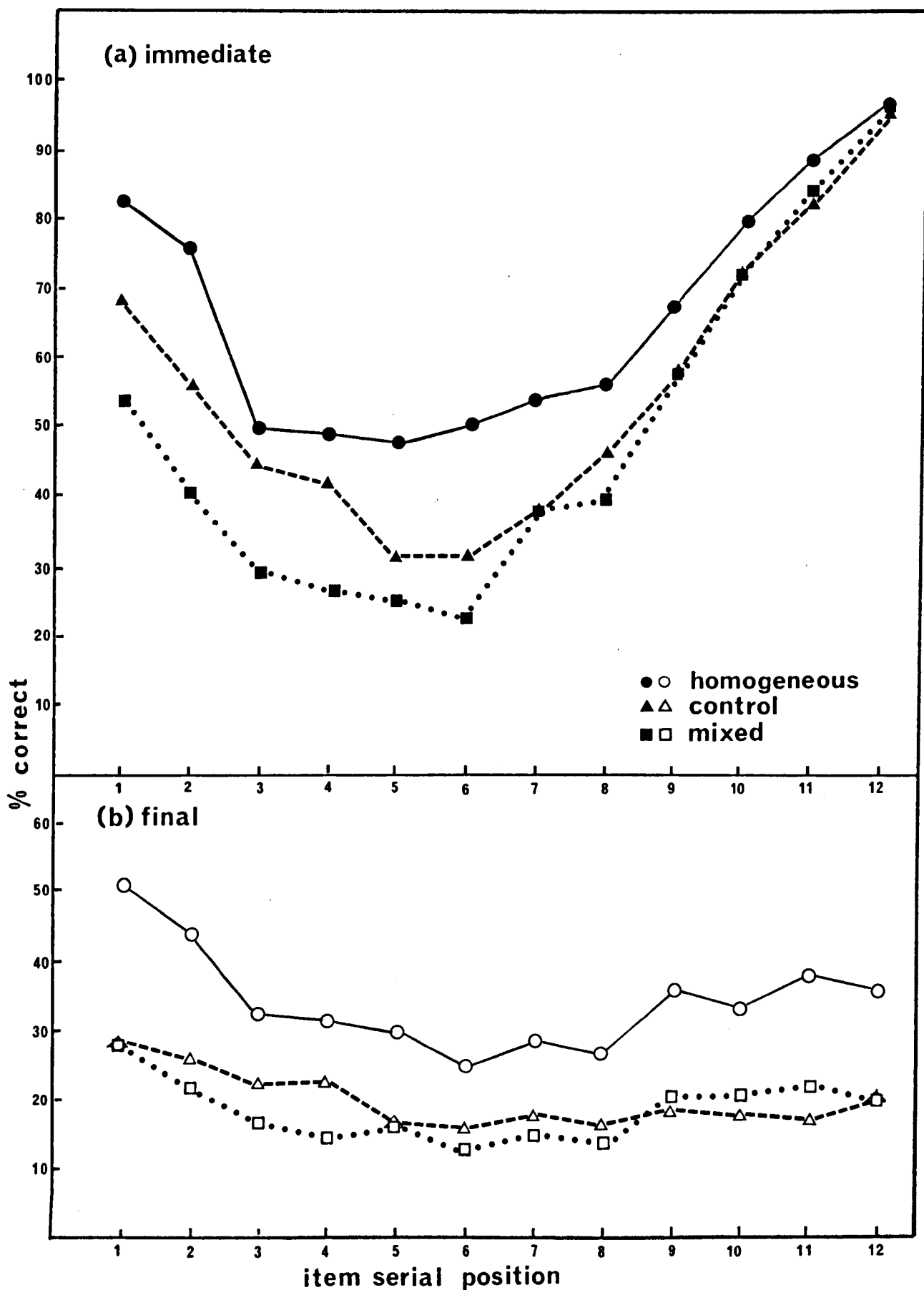


Figure 5:1 Serial position functions for individual items for all input list conditions in (a) immediate and (b) final recall.

list condition x serial position interaction was significant ($F(22,627) = 1.90, p < .01$) and finally the three-way interaction list condition x delay x serial position was highly significant ($F(22,627) = 2.49, p < .001$). From this it can be concluded that the differences in the serial position functions depicted in Figure 5:1 are statistically reliable.

List Analysis - Immediate and Final Recall

In order to examine whether there was any reliable effect of input list in the final free recall data the results were re-analysed in the following manner. Firstly the number of items correctly recalled in the immediate test was computed and expressed as a function of each input list. Secondly a similar operation was conducted on the final recall data. Once this had been done the final recall scores were expressed as a proportion of immediate recall for each list in an attempt to remove any 'noise' in the functions which may be due to certain lists by chance being recalled better initially. The functions thus obtained for each list condition are shown graphically in Figure 5:2. From this it is apparent that recall is best for terminal lists and thereafter declines monotonically as one proceeds back through the experiment towards earlier lists. Furthermore, although performance appears to be slightly higher for the homogeneous condition over earlier lists (suggesting a possible interaction) the shape of the function is essentially the same downward trend for all list conditions. The general nature of this result therefore confirms the hypothesis noted in the introductory section and suggested by the tentative evidence of Experiment 8.

The raw data obtained from this list scoring procedure were submitted to a three way analysis of variance ($3 \times 2 \times 12$). As before list condition was a between factor while delay and list serial position were within factors. This revealed significant main effects of list condition ($F(2,57) = 29.75, p < .001$), delay ($F(1,57) = 1488.69, p < .001$) and list serial position ($F(11,627) = 2.77, p < .01$). The first two main effects would be expected on the basis of the analysis conducted on individual item scores. The list condition x delay interaction was also significant ($F(2,57) = 3.26, p < .05$) as was the delay x serial position term ($F(11,627) = 7.03, p < .001$). However neither the list condition x list serial position interaction nor the three-way term, list condition x delay x list serial position reached significance ($F(22,627) = 1.05, p > .05$; and $F(22,627) = < 1, p > .05$ respectively). This last result implies that the trend for early lists to be recalled better in the homogeneous condition which is apparent in Figure 5:2 is somewhat misleading. It may in fact be

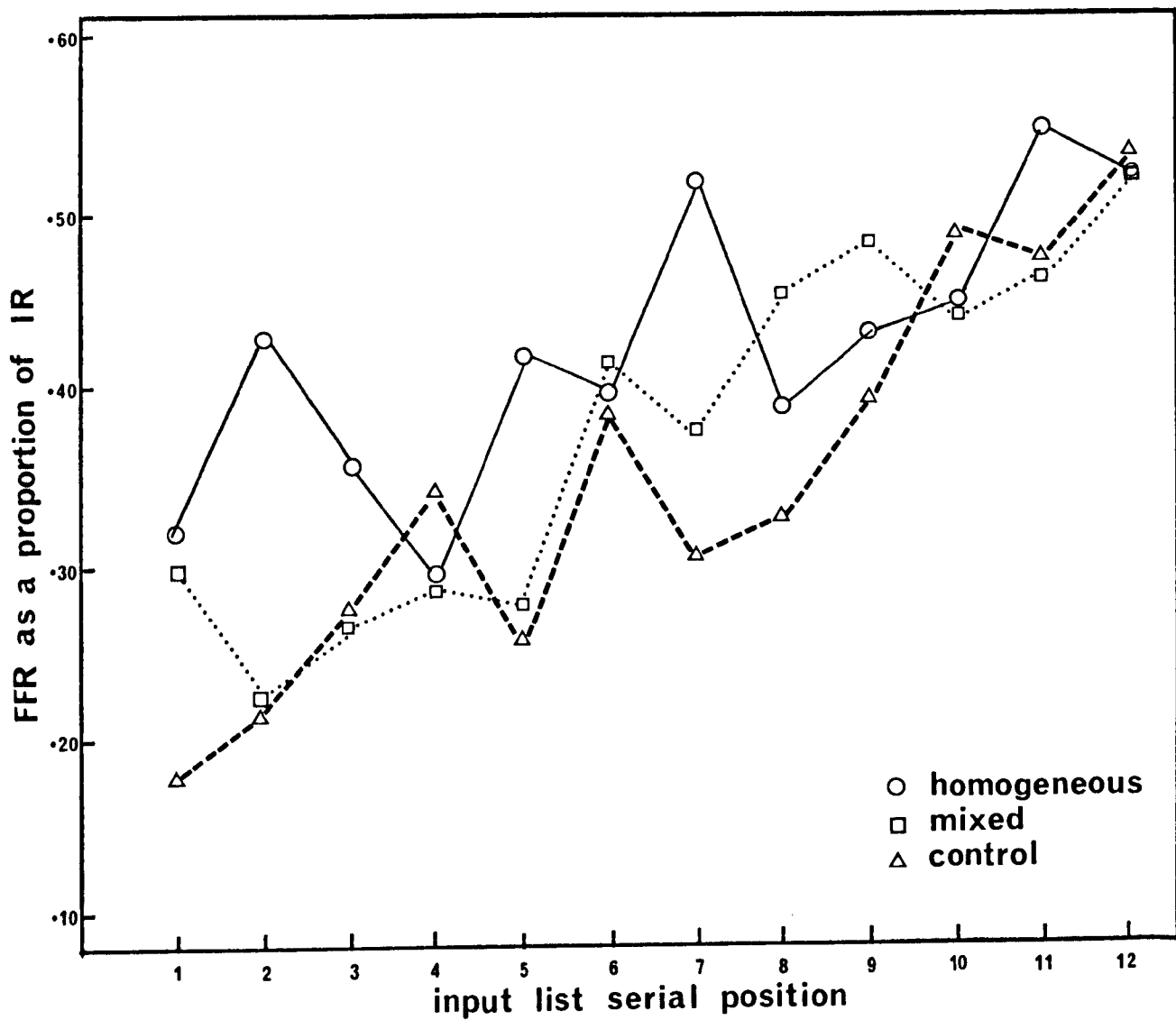


Figure 5:2 Final recall for each input list expressed as a proportion of immediate recall.

the product of the proportional averaging process performed on the data. Indeed a subsequent analysis which computed the difference scores between immediate and final recall, while revealing the same basic linear trend across list serial positions, showed the three list conditions to be much more inseparable than Figure 5:2 suggests. There are therefore no grounds for assuming that the list recency effect is affected by the nature of the stimulus material.

One final analysis of the data was carried out in an attempt to provide additional information on the list recency effect. It will be recalled that the FFR serial position data for items (Figure 5:1 b) shows evidence of positive recency for both the category conditions. That is to say that at least for semantically related material the list recency effect is a product of both early and later list item recall, rather than being merely the aggregate of primacy values (as might be predicted on the basis of any dichotomous view). However it is still unclear whether this positive recency is as evident in the recall of early lists as later ones. In order to examine for this possibility the final recall data for individual items were rescored according to whether they came from early, middle, or late input lists. The results of this analysis are shown in Figure 5:3. Of particular interest are the functions for the two category conditions. While these curves clearly differ in their overall level of performance with the homogeneous condition being consistently superior, the basic shape is remarkably similar. Furthermore it is evident that early lists contribute to the positive recency effect as well as later lists. The only inconsistency is the downward trend for the last two items in these early lists. It is not clear whether this result is in any way meaningful, and it should be noted that it may be responsible for the ultimate flatness of the positive recency effect obtained for these conditions.

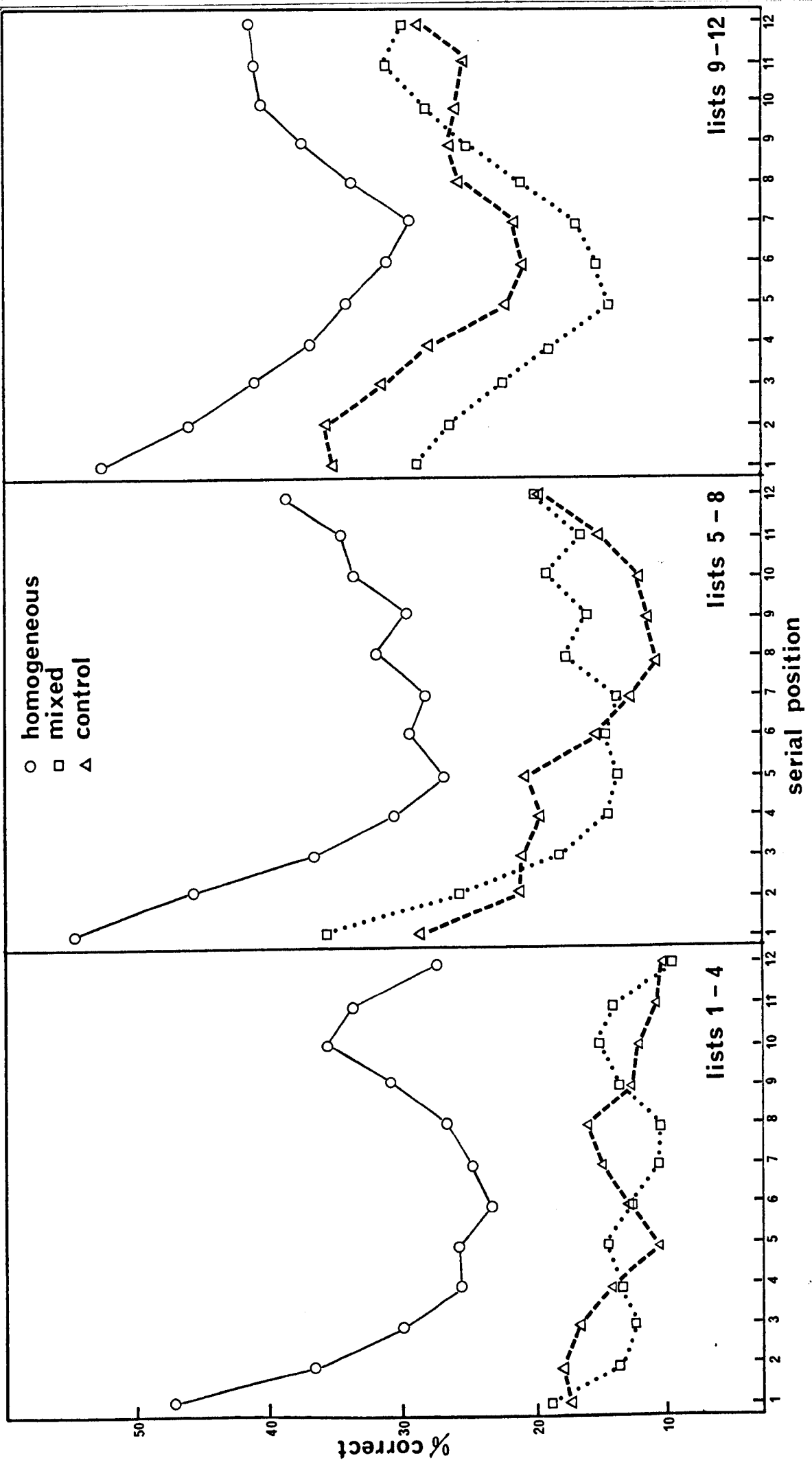


Figure 5:3 Final recall for all list conditions expressed as a function of item serial position for early, middle and late input lists.

5:3:3:1 Immediate Recall - Individual Items

Most of the major theories have little difficulty in accounting for the superior immediate recall performance on the early portion of the function for homogeneous lists. For example, dichotomous views interpret this as reflecting output from LTS, and the finding can therefore be considered analagous to the benefit which accrues to familiar or high frequency words (Sumbly 1963, Raymond 1969).

There are at least three possible reasons for this result, one of which implicates operations conducted during acquisition, while the other two refer to differences at the retrieval stage. Firstly, given that homogeneous lists, by definition, contain only items from one taxonomic category they are unlikely to be easier to encode. That is to say that semantic associations between the items are already present, and therefore no special processing of a subjective nature is required to establish such links (cf Tulving 1962). Secondly, the retrieval of such lists is likely to be facilitated by the fact that only one cue - the single category name - is required to gain access to the entire set of items (cf Tulving and Pearlstone 1966). Such a cue is always going to be available in immediate recall upon the production of any single item. The final reason, which also highlights retrieval processes, suggests that the subjects experiencing the mixed category lists may be disadvantaged relative to their homogeneous counterparts. This is because the immediate recall of items from any mixed list (after the first list) has to be conducted against a background of previously-presented items from the same categories. This in turn implies a decision stage to determine whether an item just recalled belongs to the critical list just presented or to some previously-presented, and hence now, 'irrelevant' list.

In a similar vein a levels of processing account has little difficulty in accommodating the superior level of recall for early portions of the homogeneous condition function. As pre-recency regions of the curve reflect aspects of semantic encoding (Type II processing), and as it can be assumed that the provision of semantically-related items will lead to a greater degree of elaboration encoding (Craik and Tulving 1975), this result follows quite naturally from the model.

The above explanations however cannot account so easily for the apparent recency superiority of the homogeneous lists (unless this is also supposed to be due to the long-term component). If at the time of recall terminal items are deemed resident in either STS (Waugh and Norman 1965; Glanzer 1972) or a rehearsal buffer (Atkinson and Shiffrin 1968) then the

immediate dumping of the contents of these mechanisms should produce equivalent recency regardless of the nature of the items themselves. Likewise a levels account seeking to explain free recall recency on the basis of phonemic processing would find it hard to explain why a semantic relationship amongst the items improves their recall. Indeed the result appears to be at variance with a large body of evidence which points to the invariance of recency over a wide range of experimental manipulations (cf Glanzer 1972). It may therefore be spurious; and the issue will therefore be dropped until consideration of the next experiment.

The results also have implications for alternative accounts of recency based on the operation of some form of ordinal retrieval strategy (e.g. Tulving 1968; Craik and Jacoby 1975; Baddeley and Hitch 1977). Firstly, however, as indicated earlier the very fact that a recency effect was present at all in the homogeneous condition would seem to run counter to the view formulated by Baddeley (1976). Based on a review of a large number of studies Baddeley is led to suggest that the recency effect "represents the operation of a retrieval strategy which is typically used in the absence of a more adequate strategy, such as might be provided by semantic inter-item associations" (Baddeley 1976, p.186). Such an account suggests a fairly primitive mechanism which is only called upon if no higher level organisation is available. However in the homogeneous condition there is unequivocal evidence of recency in the presence of semantic inter-item associations. To assume otherwise would require the same implausible premise encountered in connection with levels of processing; namely that semantic links are perceived and established for early list items, but not for later ones. Nonetheless, while Baddeley's (1976) view appears in need of modification to incorporate the present finding, such modification could be achieved without violating the basic principles of the retrieval strategy hypothesis. If the major determinant of the effect is considered to be for example the temporal discriminability or ordinal position of later items, then it may be unnecessary to assume that the nature of the items themselves is important.

The Craik and Jacoby (1975) account is once again in a position to handle the results by invoking one of two possible processes. If terminal items are still held within the mechanism of conscious awareness at the time of recall, then these can be output to produce recency. If this is not the case then the backward scanning operation can be performed upon the terminal items until such a strategy proves no longer fruitful.

The Bjork and Whitten (1974) model for reasons advanced earlier can only handle immediate recall recency if it can be assumed that the terminal items are in no way cumulatively rehearsed. It is unlikely that such a guarantee could ever be given with respect to immediate recall list processing.

In the first instance it is necessary to comment on the lack of a negative recency effect in final recall for the control lists (Figure 5:1 b). While this failure to replicate the findings of earlier experiments (Craik 1970; Craik, Gardiner and Watkins 1970) need not affect directly any conclusions regarding the category conditions, clearly it questions the reliability of the basic effect. The present experiment in fact is not alone in this respect; other studies by Maskarinec and Brown (1974) have reproduced data similar to that obtained here, thus adding weight to the argument that negative recency is not as general a phenomenon as originally suggested.

One explanation of the present result involves the possible consequences of the fairly fast presentation rate adopted. The rate of one item per second was chosen for reasons of pragmatic convenience; the same subjects were being tested subsequently in a totally different experiment and in order to cut down an overall time a relatively fast rate was selected. Now it is well established that fast presentation rates have a very marked effect on performance in free recall and this is reflected typically by a lowering of the primacy and middle portions of the lists (cf Glanzer and Cunitz 1966). It is also known that differential rehearsal normally takes place during acquisition with early items receiving more attention than later ones (Rundus 1971). If it is assumed that the number of rehearsals an item receives is an important determinant of the final recall of that item (a point which will be returned to later) then one possible explanation of the present result follows. With increasingly faster rates where inter-item time becomes shorter there is progressively less time to perform such cumulative rehearsal operations and hence differential rehearsal may be diminished. Stated another way, with the possible exception of the very first items, the ratio of rehearsals for early to late items may be approaching unity. It is therefore conceivable that the rate of one item per second is beginning to approach the point where there is only sufficient time to acquire each new item as it is presented, and where to engage in cumulative rehearsal groupings could only be carried out at the expense of registering later items adequately. If it is further assumed that subjects reject this latter strategy in favour of one which maximises their acquisition of all items within the list, then late items will receive roughly the same number of rehearsals as mid-list items and consequently their final recall will be similar i.e. a stable asymptotic function.

Turning now to the final free recall for both the category conditions, it seems that some form of positive recency obtains in FFR. Recall of the

last four items in both cases appears to lie above the asymptotic level, although the effect is more marked in the homogeneous condition (cf Figure 5:1 b). It will be recalled that Mazuryk (1974) obtained a similar result for words to which associates had been generated, although his procedure was open to a number of criticisms raised earlier. The present findings, assuming they represent a genuine effect, are not open to the same objections. They would also appear to pose a number of theoretical problems.

In the first place they pose very definite difficulties for a levels of processing account. Earlier it was argued that it seemed difficult to choose between an option which might have predicted negative recency (shallow processing of terminal items), and one which might have predicted a flat asymptotic function (maintenance rehearsal within the semantic level). However it is not at all clear how the model could cope with the present findings of better than asymptotic performance for terminal items in final recall. The problem of explanation however is not unique to this theoretical framework. None of the recency-only models are capable of addressing such a result either; quite simply, individual items are an inappropriate criterion on which to base any recency retrieval strategy during final recall. Perhaps the simplest explanation of the data is provided by appealing to two additional assumptions : (i) the advantage of the extra presentation which items may receive as a function of being recalled in the immediate test, and (ii) the fact that such an advantage may only carry over into final recall if an appropriate retrieval cue is available to access the items. The explanation is somewhat post hoc, but is not entirely implausible. For example, Tulving (1967) has already suggested that a recall trial can function as an additional learning trial. Further, because recency items are well recalled in immediate recall, they are therefore in a better position to benefit from such additional 'learning'. Finally, the presence of positive recency in both the conditions containing related material is strongly suggestive of the value of the semantic retrieval cues in accessing the items. The only remaining problem would be to explain why the positive recency portion obtained assumes an essentially flat shape. On this point the curves for early, middle, and late lists in Figure 5:3 suggest that this might be some artefact of averaging across certain inconsistent serial positions. If this line of reasoning is correct, and it must be admitted that it is somewhat speculative, and presented in the face of somewhat atypical, and unexpected results, then it should be noted that it is not easily encompassed within existing models. Perhaps only some version of the positional distinctiveness theory, where list endings can presumably also act as retrieval markers - especially when associated with distinct conceptual units (homogeneous condition) - could address the phenomenon.

5:3:3:3 Final Free Recall - The Effect on Input Lists

The second major issue motivating the experiment was whether or not there was any regular relationship when final recall was plotted as a function of input lists (rather than merely the conventional measurement of item serial position). In particular the experiment sought to discover whether recency-like functions would characterise the input list curves. In this respect the experiment was unequivocal. Figure 5:2 shows clearly that when the data are scored in this way, the resulting function appears to be monotonically decreasing from the last lists which exhibit the best performance.

A full discussion of the theoretical implications of these results will be postponed until Experiment 10 has been reported. In the meantime several features of the data should be noted :

- (i) If these functions are to be included as further examples of recency phenomena, the effects once again span units considerably larger than the individual words measured in traditional free recall tests.
- (ii) The effects are clearly 'long-term' in the sense that the presentation of other whole lists and their subsequent recall have intervened before final recall was demanded.
- (iii) The results cannot be attributed to differences in the acquisition of the lists. This has to be the case for at least two reasons. Firstly, as the subjects had no prior knowledge of the final recall test, they could therefore not be expected to devote any further attention to any one list once it had been recalled in the immediate test. Thus there would be no reason to assume that they would be rehearsing any more than one list at any one time during presentation, and certainly not the last few lists immediately prior to the unexpected final free recall. Secondly, the data in Figure 5:2 displays the final recall scores expressed as a proportion of the immediate recall for each list. Such a procedure would tend to eliminate any differences due for certain lists, by chance, producing atypical scores and affecting the function.
- (iv) Although there appear to be slight differences between the list conditions, these were not significant, and the essential shape of the function is similar for all types of input material tested.

While detailed consideration of these issues will be returned to later, certain comments can be made at this stage. As examples of recency phenomena the above results cannot be explained in terms of output from any short-term store, or primary memory mechanism, or rehearsal buffer. This immediately rules out conventional explanations based on versions of the modal model, and subsequent work based on a levels of processing approach. The above results are much more amenable to explanation in terms of ordinal

retrieval strategies or backward scanning processes operating on appropriate units at the time of recall. In this context it is instructive to note that the crucial factor appears to be the input list itself and its ordinal position within the list series. Changes in the material which comprise each list appear to have no effect upon the basic nature of the function. The reliability of this finding will be tested in Experiment 10 before its full importance is assessed. Furthermore, as one consistent finding in experiments which employ material made up of several categories is the loss of certain items due to the total omission of whole categories from recall (Tulving and Pearlstone 1966), it is necessary to evaluate the exact contribution of such a factor upon the determination of the form of recency effects obtained in the two category conditions. For example, the function for the homogeneous condition might be reflecting an effect of the same type as the category recency finding of Experiment 8 in the previous chapter. On the other hand, the fact that the homogeneous condition does not appear to differ from the other list conditions tested - with regard to the list recency effect - strongly suggests that the only crucial factors are the initial attempts to learn any list for immediate recall, and the position of the list in the input series. A valuable test of these issues would be given by the inclusion of a cued final recall where the names of the categories themselves are provided as an aid.

The main findings of Experiment 9 can be summarised by the following brief points :

- (i) When categorised material is presented to subjects for immediate recall, typical serial position functions are obtained exhibiting both primacy and recency components. When the related material is arranged such that each list contains only items from one category, recall will be superior to lists where each item represents a different category, or lists composed of totally unrelated items.
- (ii) Final free recall of semantically related material appears to show some evidence of positive recency (regardless of presentation format) when compared to control lists of unrelated material. The latter condition however did not show evidence of negative recency, and it remains a somewhat open question as to how reliable such effects are.
- (iii) When final recall is plotted as a function of input list, a list-recency effect is obtained which appears to be independent of the material making up the lists.

While some of the theoretical implications of these results were discussed, it was noted that a full evaluation should be postponed until certain features of the paradigm were altered to provide a more complete picture of the effects. In this context the following points can be made, (the potential importance of some of these with regard to influencing the effects has already been noted) :

- (a) The list length selected was somewhat shorter than that normally employed in such experiments.
- (b) The rate of one item per second is also faster than the typical presentation rate adopted in free recall tasks, especially when semantic material is being employed. This may be important if it is assumed that the establishment of certain semantic relationships takes time to complete (e.g. Baddeley and Levy 1971).
- (c) No instruction was given to the subjects to output terminal items first during immediate recall.
- (d) Although all categories in the mixed condition lists were presented at all serial positions, there was no attempt to locate the same words at the same serial positions as in the homogeneous condition.

Uncontrolled combinations of some or all of these factors could have influenced the recency effects for individual items obtained under both immediate and final recall tests.

- (e) In the light of the potential importance of the list recency finding, the lack of a cued final recall for the category conditions is an important omission in any exercise to evaluate the processes responsible.

In the light of these observations therefore it was decided to replicate the category conditions in a further experiment with tighter controls and a condition designed to tease out the list effect more adequately.

5:4:1 Method

Stimulus Material and List Construction

The same basic methodology was used as in Experiment 9 with some important refinements. Firstly the Battig and Montague (1969) category norms were consulted to provide 16 exemplars of each of 16 selected categories. Once again the categories themselves were selected to be as different from each other as possible. The total word pool thus obtained (256 items) was then re-assembled to give the two basic conditions : homogeneous and mixed. In the homogeneous case each list contained only items from one category, while in the mixed condition each list contained one example of each of the categories. One further refinement was imposed upon list construction in order to equate the conditions with respect to the last five items in each list i.e. serial positions 12-16 inclusive. (The choice of five was intended to cover those items usually encompassed by the recency effect). This was that the items had to be located at the same serial position in both homogeneous and mixed conditions. Thus if the word 'Sparrow' from the category 'Bird' appeared in serial position 16 in the homogeneous condition, it also had to be located at serial position 16 in one of the mixed condition lists, thus preserving item identity across the recency portion in both list conditions. For positions other than the last five (i.e. 1-11 inclusive) the mixed condition was only constrained to ensure that each category was represented at all serial positions. Within the limits set down by the above rules, each subject was presented with a fresh randomisation of the material.

Design and Procedure

Again a between subjects design was employed where subjects were allocated at random to either the homogeneous or mixed list condition.

Prior to testing the nature of the free recall task and the structure of the lists they would experience was described in full to the subjects. It was emphasised that as soon as presentation of each list had ceased recall was to begin immediately with terminal items being output first. Only after this had been completed was recall of earlier items to be attempted. No practice lists were administered because of the possible confounding effects of introducing additional categories into the experiment.

Lists were read out to the subject at a rate of $2\frac{1}{2}$ seconds per word as timed by an electronic device which flashed a light within the Experimenter's field of view. Following presentation of each list 2 minutes were allowed for subjects to write their recall in a response booklet provided. A fresh page was used for each list.

Once recall of the last list had been completed, the response booklet was collected by the Experimenter and a fresh sheet of paper was issued to the subject. At this point subjects were asked to perform the second, and unexpected recall test where they were to attempt to reproduce as many words as they could from the entire set of 16 lists. A maximum of ten minutes was allowed for this activity although most subjects' recall ceased well within this time period.

When subjects were sure that they had recalled as many items as they could they were asked to draw a line under the last item written on their sheet. At this point they were shown a card on which was printed the 16 category superordinates. This was left in front of them while they were asked to recommence recall using the cues thus provided. A further five minutes was allocated for this cued recall phase, although again subjects tended not to have to use the maximum permitted time.

Subjects

A total of 40 undergraduate students from the Part I Psychology course at the University of Stirling served as subjects in the experiment. They received a course credit for their participation. Subjects were assigned randomly to the two conditions of list construction to yield two groups of twenty subjects.

5:4:2 Results and Preliminary Discussion

Individual items - Immediate Recall

The number of words correctly recalled was calculated for each of the two list conditions. These results expressed as percentages for each input serial position are depicted in Figure 5:4 (a). It is immediately obvious from this that while the homogeneous condition again displays superior performance over the primacy and middle portions of the list, the two conditions yield identical recall values for the last three list positions. It thus appears that preserving item identity over terminal items, and ensuring by instruction that these items are recalled first has removed the apparent difference in recency between the conditions which was found in Experiment 9.

Individual items - Final Recall (uncued scores)

Once again only those words recalled in the immediate test were scored for principal analysis in final free recall. These data obtained under uncued conditions are shown in Figure 5:4(b). Unlike the results of

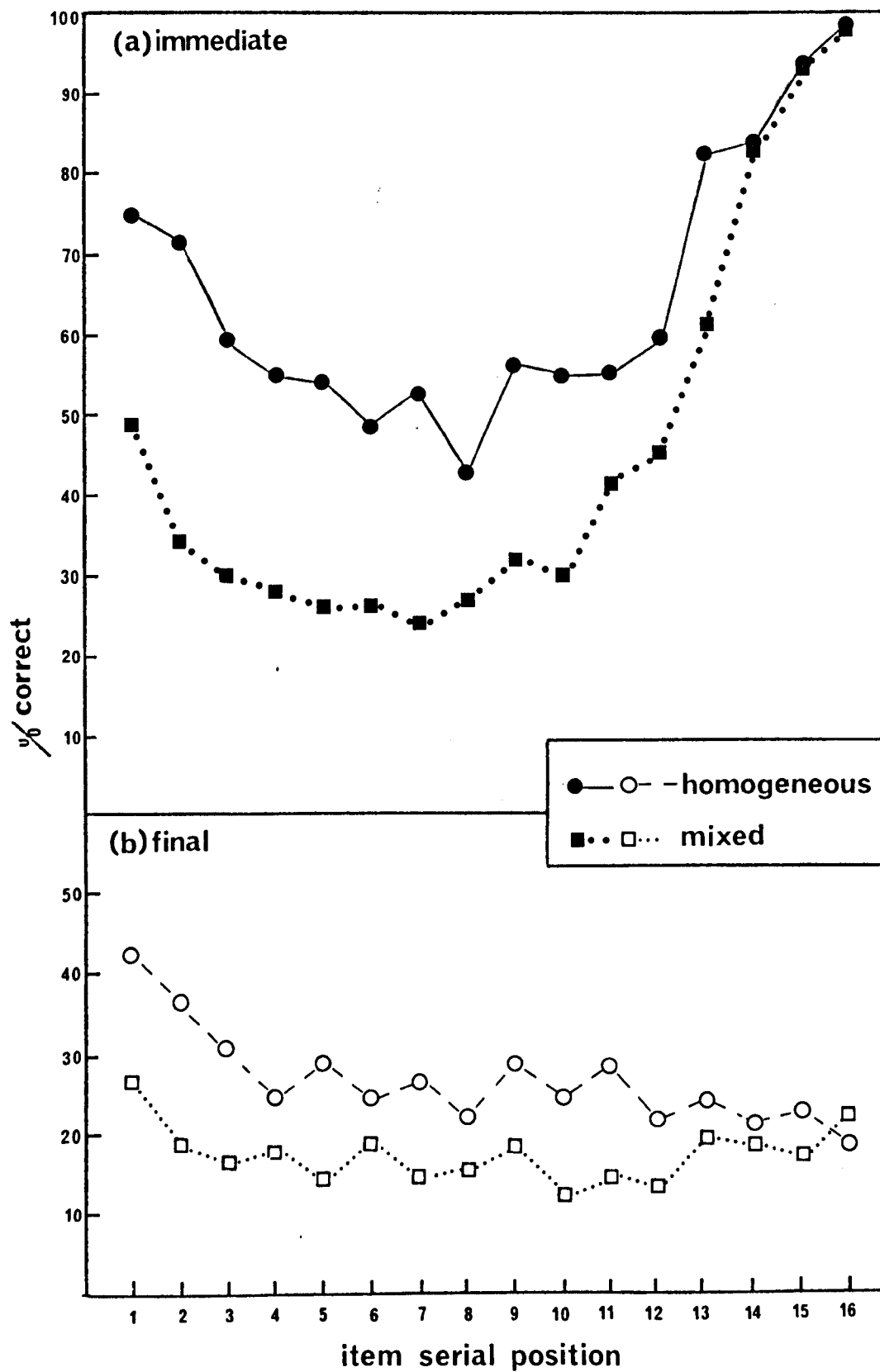


Figure 5:4 Serial position functions for individual items for both input list conditions in (a) immediate and (b) final recall.

Experiment 9 this analysis now reveals positive recency for the mixed condition lists and negative recency for the homogeneous condition. This result is clearly worthy of particular attention, especially in the light of the equivalent performance exhibited by these conditions in immediate recall recency. It will therefore be returned to for fuller discussion later.

A three factor analysis of variance ($2 \times 2 \times 16$) was carried out on the raw data from the above scoring procedures. This treated list condition as a between subjects variable and delay and serial position as within subjects factors. This yielded significant main effects of list condition ($F(1,30) = 33.97, p < .001$), delay ($F(1,30) = 1215.72, p < .001$) and serial position ($F(15,450) = 42.15, p < .001$). In addition, as expected the list condition \times delay interaction was significant ($F(1,30) = 32.22, p < .001$) demonstrating that homogeneous lists are more detrimentally affected by delay. Also the list condition \times serial position term was significant ($F(15,450) = 6.24, p < .001$). As noted earlier reference to Figure 5:4 shows that the difference between the conditions is restricted to earlier list positions in immediate recall. Finally the three way interaction of list condition \times delay \times serial position was significant ($F(15,450) = 3.81, p < .001$). Interpretation of this result is not entirely straightforward. As indicated by Figure 5:4 some of the effect may be due to differences in recency between the conditions when going from immediate to delayed recall. However it is probably the case that most of the effect is explained by the fact that the relative reduction in homogeneous superiority with delay is greater for earlier positions.

List Analysis - Immediate and Final Recall

As in Experiment 9 the data were rescored as a function of input lists for both the immediate and final recall tests. The results of this analysis are presented graphically in Figure 5:5, where the upper panel (a) depicts immediate recall, the centre panel (b) illustrates uncued final recall and the lower panel (c) shows final recall including cued recall. These data reveal one slight departure from the results of Experiment 9. Panel (a) shows that while the immediate recall function for homogeneous lists is relatively horizontal, the equivalent curve for the mixed condition declines over the first few lists before stable performance is achieved. While there was a trend in this direction in the comparable condition in Experiment 9 the tendency was not nearly so obvious. Such a result could of course be predicted on the basis of a build-up of proactive interference brought about by the presentation of successive instances of the same

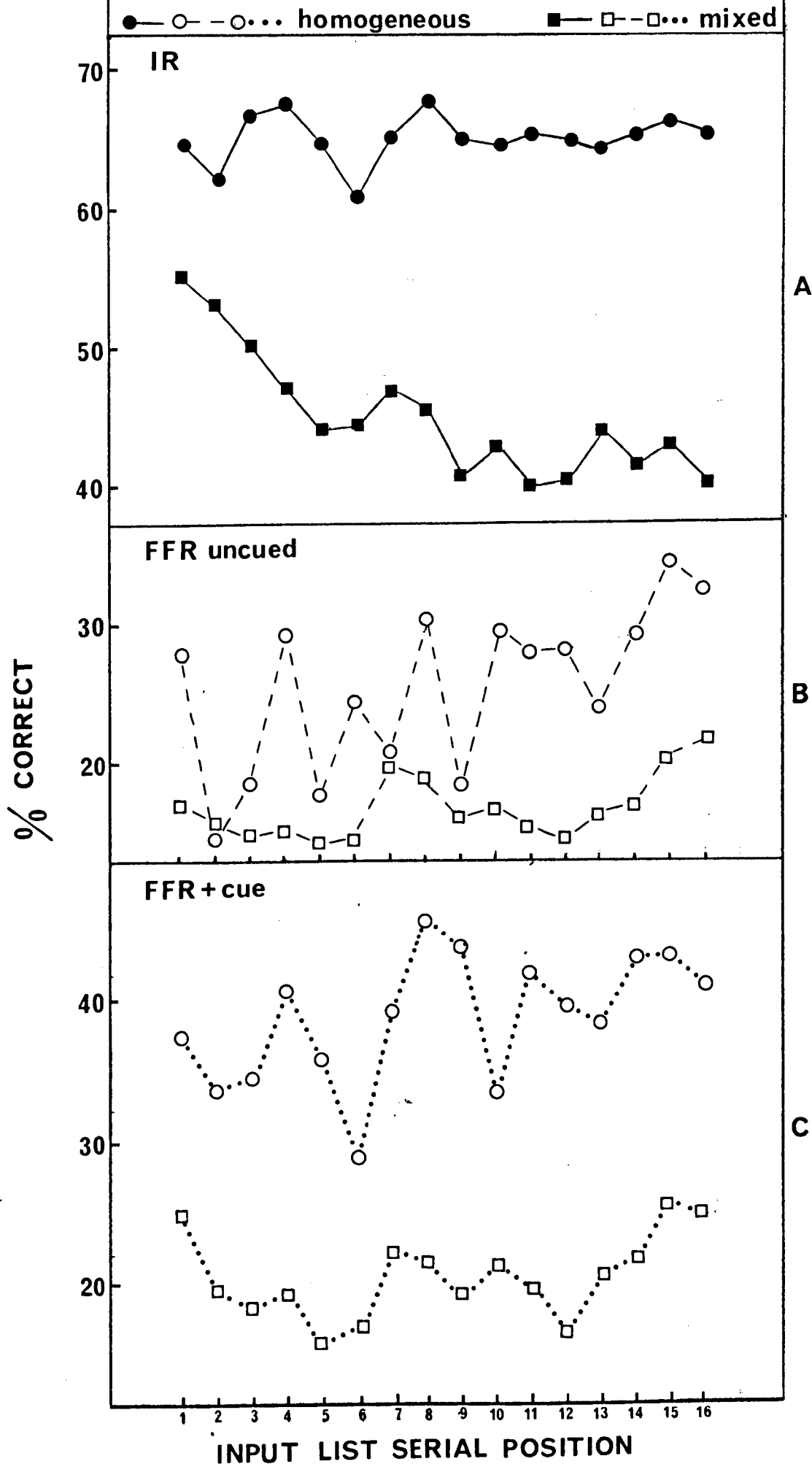


Figure 5:5 Immediate and final recall as a function of input list.
 A = immediate recall; B = uncued final recall;
 C = cued final recall.

categories in the mixed condition lists. Final recall (panel b) again shows evidence of later lists being retained better than earlier ones and this effect is most evident in the homogeneous condition. Final recall including the additional items retrieved with the aid of category cues (panel c) reveals that the homogeneous condition receives a greater benefit from such cues, and further that this benefit is more evident for earlier lists where clearly more categories were less accessible (cf Tulving and Pearlstone 1966).

A three factor analysis of variance was performed on the raw data from the immediate and delayed tests as depicted in Figure 5:5 panels (a) and (b). List condition was a between subjects factor while delay and list serial position were within subjects factors. This produced significant main effects of list condition ($F(1,30) = 32.97, p < .001$) and delay ($F(1,30) = 1208.87, p < .001$) but not for list serial position ($F(15,450) = 1.14, p > .05$). The list condition \times delay interaction as might be expected from Figure 5:5 was highly significant ($F(1,30) = 31.90, p < .001$), although the list condition \times serial position term just failed to reach significance ($F(15,450) = 1.51, p > .05$ (required value = 1.70)). The most marked effect upon list serial position was clearly the time of the recall test as witnessed by the significant delay \times list serial position interaction ($F(15,450) = 2.50, p < .01$). The three way term list condition \times delay \times list serial position was not significant ($F(15,450) = 1.18, p > .05$).

A further three way analysis of variance ($2 \times 2 \times 16$) was conducted on raw data from the two final recall tests represented by Figure 5:5 panels (b) and (c) in order to determine the effects of the category cues. This revealed significant main effects of list condition ($F(1,30) = 23.71, p < .001$), category cue ($F(1,30) = 120.8, p < .001$) and list serial position ($F(15,450) = 1.82, p < .05$). Further the significant interaction of list condition \times category cue ($F(1,30) = 46.41, p < .001$) confirms that the homogeneous condition benefits far more from the provision of cues during retrieval. The list condition \times list serial position term was not significant ($F(15,450) = < 1$), however the three way interaction list condition \times category cue \times list serial position did reach significance ($F(15,450) = 1.78, p < .05$). This offers some tentative support to the conclusion that the benefits which accrue to the homogeneous condition under cued recall predominantly have their effect on earlier lists, while the effect on mixed lists is more evenly distributed. However as this is perhaps only clear for the last 2 homogeneous lists it has to be admitted that idiosyncratic serial position effects, and the very large degrees of freedom present in the error term, may well have contributed to the significance of this result.

The effects are perhaps best illustrated by recourse to the proportional analysis adopted in Experiment 9. Figure 5:6 therefore depicts final recall for each list condition expressed as a proportion of immediate recall for each input list. Panel (a) in this figure represents uncued recall, while

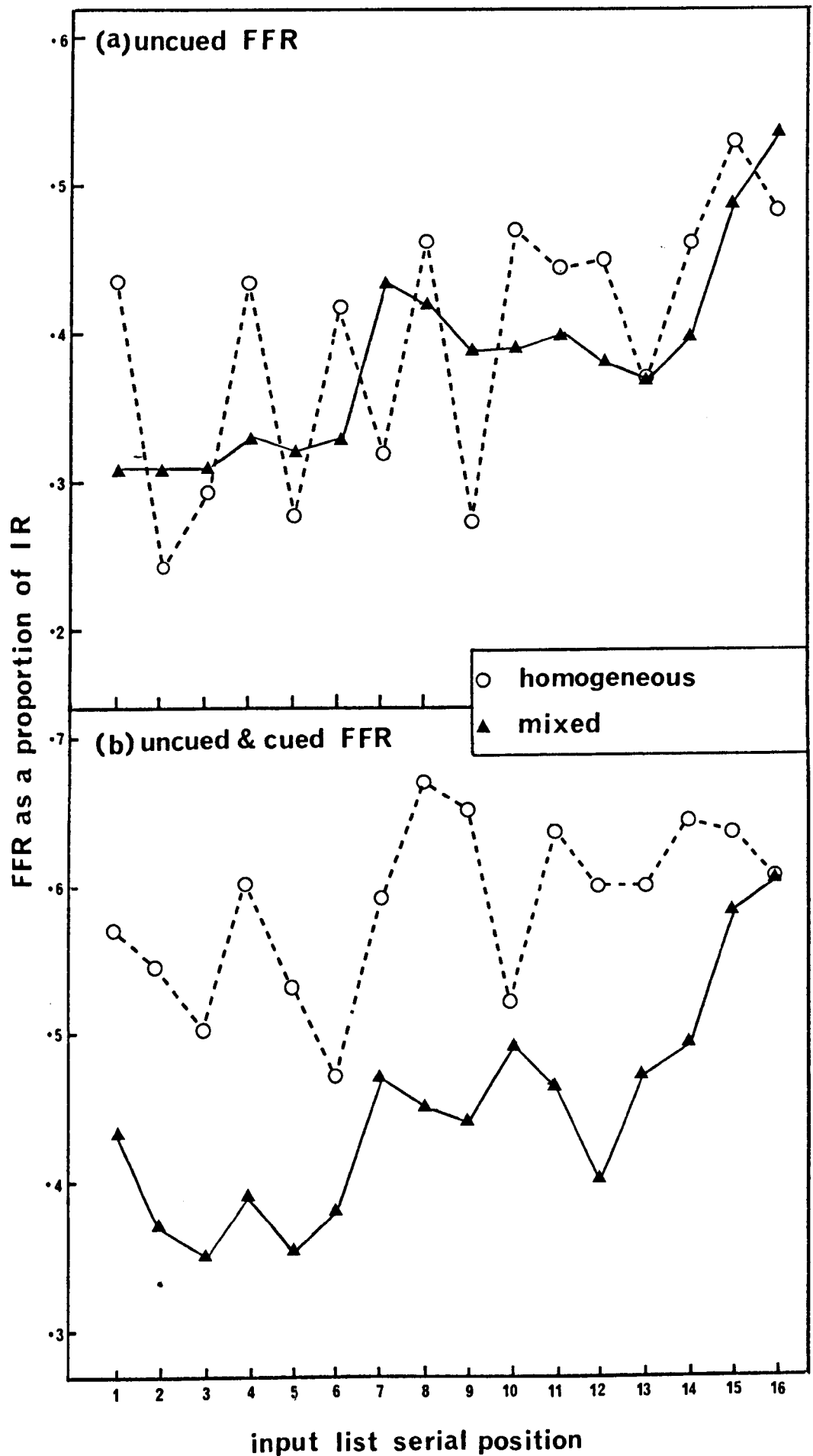


Figure 5:6 Final recall expressed as a proportion of immediate recall for each input list, and both types of material. Panel (a) - uncued final free recall; panel (b) - uncued plus cued final free recall.

panel (b) includes the additional items retrieved when cues are provided. Such an analysis removes any possible confounding due to differences in immediate recall levels, whether these are caused by chance factors or for example the possible presence of such phenomena as PI noted in the mixed condition. Figure 5:6 shows in fact that in the absence of cues (panel a) the two types of list behave in a remarkably similar fashion. Although the function for homogeneous lists appears more erratic it is clear that any averaging procedure applied to the data in order to 'smooth' the graph would be likely to show that for any one input list, performance is roughly the same proportion of immediate recall irrespective of list condition. Furthermore this proportion shows a steady decline with less being retained for earlier lists. However the fluctuations in the homogeneous condition do make it impossible to establish whether the relatively high performance achieved on the first list is a true reflection of the memorability of that list (a sort of list-primacy effect) or merely some random variation.

The picture is quite different when the category cues are taken into account (Figure 5:6 panel b). In this case retention of the last list is again virtually the same for both list types. Thereafter however the function for mixed lists tails off more steeply (in a manner similar to uncued final recall for that condition) while the function for homogeneous lists is maintained at a higher level with only a gradual deterioration in performance towards earlier lists. These results permit certain conclusions to be drawn :

- (1) The level of final recall for each list is directly related to its distance from the end of the session, with recent lists being retained better than earlier ones
- (2) For homogeneous lists this relationship seems predominantly the product of category loss (cf Tulving and Pearlstone 1966) while for mixed lists it seems determined in the main by item loss. In addition this result emphasises the crucial importance of the encoding context during learning in determining the value of retrieval cues.
- (3) Furthermore the functional equivalence of these two effects exhibited in the uncued recall data demonstrates that the retention of retrieval rules or cues can be governed by the same factors as determine item recall.

One further analysis of the final recall data examined the serial position for items as a function of early and late lists in the input sequence. This serves the dual purpose of determining whether the final recall data as depicted by Figure 5:4(b) is representative of all lists,

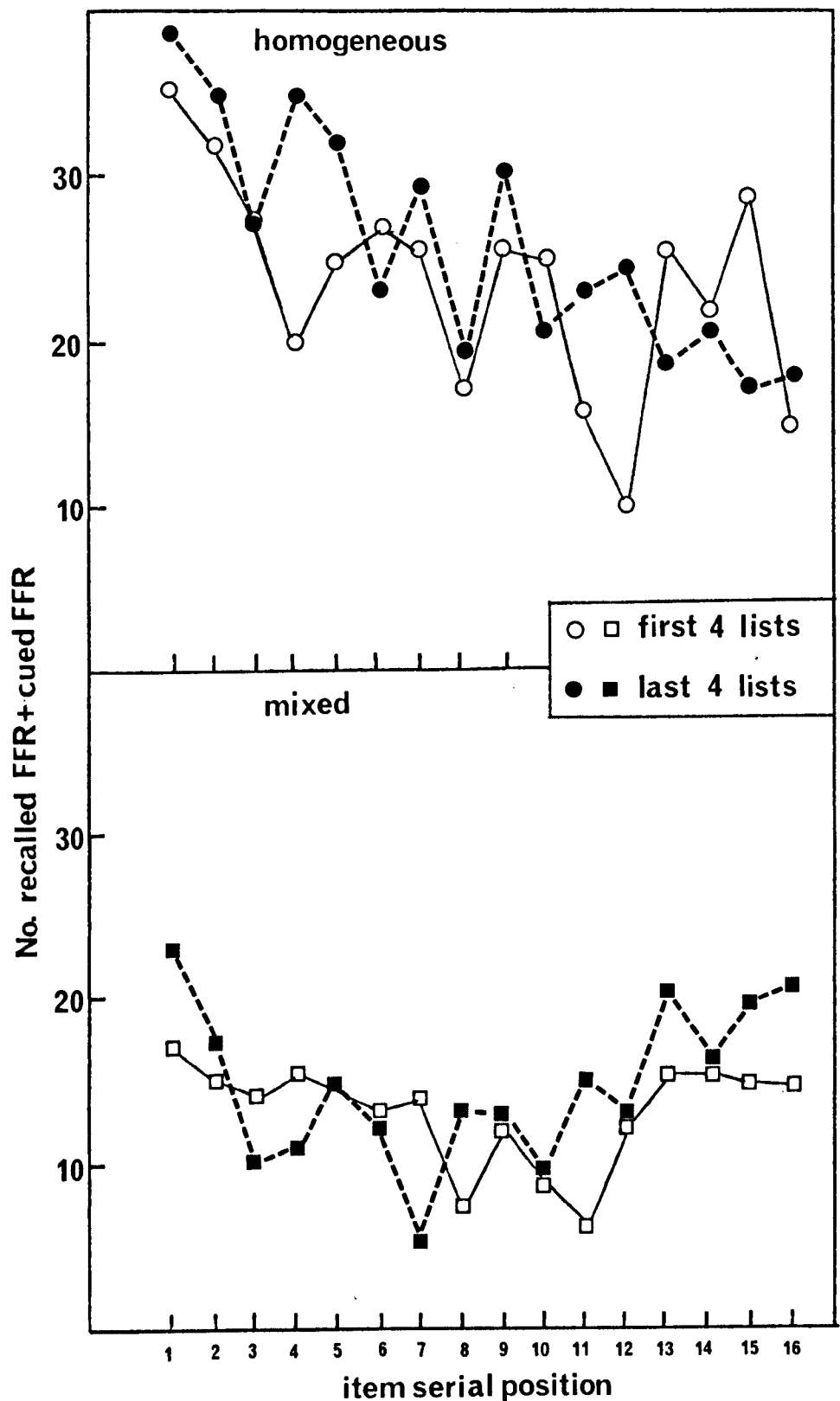


Figure 5:7 Final recall for homogeneous (upper panel) and mixed (lower panel) lists as a function of item serial position for early and late lists.

while simultaneously identifying which items in any list are contributing to the list effect described by Figure 5:6. To this end the first four and the last four lists were selected arbitrarily to represent early and late lists respectively, and the data from both uncued and cued final recall were pooled for the analysis. These results are shown graphically in Figure 5:7 where the upper panel depicts performance in the homogeneous condition and the lower panel the equivalent for mixed lists. It is apparent from these figures that the position the list occupied in the presentation sequence has very little effect upon the basic shape of the function for either type of list. For homogeneous lists, performance declines fairly steadily from early to late items (although there are some inconsistencies in the later part of the function for lists 1-4); while mixed lists consistently show a bow-shaped curve where primacy and recency portions are of approximately equal levels.

Final recall for items therefore appears to be of a relatively stable nature across all lists in the input sequence. In addition, the list effect in the homogeneous condition is made up predominantly of early items, while the effect for mixed lists appears to be more of a composite of early and terminal items.

Various issues are raised by the results of Experiment 10, some of which clarify and extend features of the previous experiment, while others appear to make the position more complex. The results of both experiments therefore will now be drawn together in a general discussion.

5:5:1 Immediate Recall - Individual Items

(i) The Advantage of Homogeneous Lists : Firstly it is confirmed (by both experiments) that the immediate recall of lists which contain only items from one taxonomic category is superior to that of lists where every item represents a different category. This can be taken as further empirical evidence of the limiting factor on the improvements in recall which are brought about by increasing the number of categories within a list as discussed in Chapter 4. Where each item is taxonomically distinct (the extreme case of increasing the number of categories), no objective relationship links the material, and for all practical purposes the list can be viewed as containing unrelated items.

The benefit thus afforded homogeneous lists therefore seems likely to be a product of the combined effect of operations occurring during acquisition and retrieval phases. At intake, the semantic link is already established, while during recall, knowledge of category membership restricts response selection to a small subset of relevant items. For mixed lists however, identifying the category membership is unlikely to prove of much value in immediate recall, and the subject is probably required to engage in more idiosyncratic strategies (cf Tulving 1962). Furthermore, during recall, the position of mixed list subjects is complicated by the fact that retrieval has to be conducted against a background of previously acquired items from the same categories. This is considered more fully in the next section dealing with the immediate recall of lists.

(ii) The Locus of the Advantage : Differences in performance attainable with homogeneous and mixed lists is now quite clearly established as pertaining to pre-recency portions of the serial position curve. While Experiment 9 appeared to indicate that the effect was possibly also present across the recency portion, the tighter controls employed in Experiment 10 have produced results which permit a rejection of this conclusion. When item identity is preserved across terminal serial positions in both conditions, and output order is controlled, no differences in recency exist. This again echoes most previous studies where single items make up the stimuli in free recall lists (cf Glanzer 1972).

The above findings are completely compatible with the modal model where the advantage noted would be expected to appear in the secondary memory or long-term component, while the primary memory of short-term mechanism is merely governed by capacity, and not the relatedness or otherwise of the material (Waugh and Norman 1965; Atkinson and Shiffrin 1968). Similar prediction emerges from a levels of processing view as far as the pre-recency portion is concerned. Thus the homogeneous lists are likely to lead to a richer encoding and this is bound to be reflected in the region deemed to reflect Type II processing (Craik and Tulving 1975). With regard to the recency-only models one implication of the findings is that recency can clearly occur in the presence of inter-item associations (cf Baddeley 1976). Further the overlapping functions obtained under the conditions of Experiment 10 suggest that output order is an important factor with regard to operating the retrieval strategy (in accordance with the results on category recency in Chapter 4). It should be pointed out however that apart from these minor points, and a lingering uncertainty over the levels account of recency, the effects reported do not substantially challenge any one model, or distinguish between them.

5:5:2 Immediate Recall - Lists

Experiment 9 tended to indicate that the proportion of words recalled at the immediate test was roughly constant for all lists, although the level of performance achieved was dependent upon the list condition with homogeneous lists being consistently superior. Experiment 10 however has shown that while this is still the case for homogeneous lists, mixed condition lists displayed a tendency for performance to decline over the first four lists after which asymptote was reached. (In fact when the equivalent condition in Experiment 9 is examined closely a similar tendency is observed although the trend is considerably weaker). The effect is evidently another example of pervasive influence of proactive inhibition (PI). It seems likely that the reason for the strength of the effect in Experiment 10 compared to its relative weakness in Experiment 9 is related to the difference in presentation rate used in both experiments.

As will be recalled from discussion during an earlier section, despite the fact that PI has been demonstrated as a reliable phenomenon in countless experiments there is still no commonly agreed theoretical account of its operation. Nevertheless certain recent experiments seem to implicate processes occurring during retrieval (eg Gardiner, Craik and Watkins 1972; Watkins 1975). The Gardiner et al study is particularly illuminating on this point. During presentation of a series of trials containing the names of flowers, a group of wild flowers was introduced at the end of the sequence without subjects appearing to register the subtle change. Under these

circumstances the typical PI effect was observed. However one group of subjects was informed of the fact at the time of recall, and showed substantial 'release' effects (cf Wickens, Born and Allen 1963; Wickens 1970) which can clearly only be attributed to retrieval processes.

Such a retrieval explanation would also account for the more dramatic PI effect experienced in Experiment 10 where presentation rate was slower. Under such circumstances there is more opportunity for rehearsal and therefore a better chance of encoding the items more durably. Thus with succeeding lists the subject is faced with the task of retrieving the correct items against a background of strongly-acquired previous items from the same categories. Under these conditions the discrimination aspect of the retrieval process which is necessary to distinguish items belonging to the relevant list from those learned during earlier lists becomes more difficult.

It should also be noted that one possible criterion for guiding the application of this discrimination process could be some form of 'recency judgment' which attempts to evaluate the relative temporal distances at the time of testing. If so, it points to yet another example of recency-sensitive retrieval (Bjork and Whitten 1974) in the context of a different phenomenon. The fact that PI builds up to a maximum over the first few trials in Experiment 10 and thereafter performance remains fairly stable is in line with most observations of the effect (see Wickens 1970). This would also be in accordance with the recency discrimination hypothesis noted above. Beyond a certain number of intervening trials, the traces from earlier lists are so relatively weak (in the proximal sense) as to pose no threat of confusability with the current list being tested.

It is also tempting to speculate on the parallel that appears to exist between the number of trials over which PI exerts its progressive influence (typically around four) and the number of items which normally make up the standard recency effect in free recall. After all, as noted above, some current views on the operation of PI are tending to favour a recency discrimination mechanism, as are certain current models of recency effects (Bjork and Whitten 1974; Baddeley and Hitch 1977). And while the ages of the relevant memory traces in these two experimental situations are hardly comparable in an absolute sense, it may well be that their relative age in the paradigm in question is the crucial factor. This however represents something of a digression, and must remain highly speculative at this stage. It should merely be noted that accounts of two phenomena appear to be advancing towards explanations based on similar mechanisms. Future research into these issues should bear this in mind.

(i) The Pre-recency Component : Both Experiments 9 and 10 demonstrate that homogeneous list retention will survive periods of intervening delay better than mixed lists. This effect is most clearly witnessed over the early, pre-recency, area of the functions. As such the finding is in accordance with the assumptions of both the major theoretical accounts considered. However the position with regard to what occurs to recency items is much less clear.

(ii) The Recency Portion : It will be recalled that Experiment 9 appeared to offer some tentative evidence of positive recency in the final recall of those lists containing semantic material, but not for lists containing unrelated material. Assumptions regarding the additional learning effect of the recall trial, and the necessity of an appropriate semantic cue were invoked to account for such findings. Such a picture however is clouded by the functions obtained in Experiment 10 which appear to replicate a small positive recency effect for mixed condition lists, but a negative recency effect for homogeneous lists. If these represent genuine effects such asymmetry is puzzling in the light of the consistent direction of the effect in Experiment 9. At this juncture it should be noted that the experiments conducted have now thrown up apparent evidence of positive, negative, and even flat recency functions in final recall. In the light of this, and in view of the very small magnitude of any such effects, it has to be suggested that the phenomenon (or phenomena) seems rather unreliable. Furthermore, such inconsistencies would appear to make satisfactory prediction, by any model, extremely difficult. Before going on to discuss some of these it is worth recapitulating the differences in the conditions between the two experiments.

The two major changes involved list length and presentation rate. The list length was increased from 12 to 16 items for Experiment while presentation rate was reduced to one item every $2\frac{1}{2}$ seconds. In addition, owing to the basic feature of the experimental design which required to equate the number of items within a list, with the number of categories being employed, the increase in list length to 16 items also meant a corresponding increase in lists. Increases in list length are known to reduce primacy and asymptotic portions of the free recall function (cf Murdock 1962), while decreasing the presentation rate typically raises performance over the same regions (Glanzer and Cunitz 1966). At first sight therefore neither of these manipulations seems to speak directly to the findings under consideration, and may even be viewed as partially cancelling each other out. Several different theoretical accounts of negative recency will now be examined, firstly to determine whether they

are capable of satisfactory modification to accommodate the findings of positive recency obtained, and secondly, to see whether they can handle the asymmetric effects.

As indicated in the introductory section, the Modal model is normally assumed to give an extremely good account of the negative recency effect, owing to the fairly perfunctory attention devoted to terminal items. The model (particularly the version of Atkinson and Shiffrin 1968) receives additional support on this point from the rehearsal data of Rundus (1971) who showed a monotonically decreasing function through the input serial positions. Indeed when this rehearsal data is compared with the original demonstration of negative recency (Craik 1970) the 'apparent' correlation is dramatic. It is not immediately obvious however, how this model could be made to accommodate any findings of positive recency in final recall, nor if this were to be the case, how it could then cope with the asymmetric effects obtained in Experiment 10.

The same basic problem exists for levels of processing approaches. There would not appear to be any particular reason for the subjects to engage in elaborate encoding (Craik and Tulving 1975) of the terminal items, especially as this runs contrary to the assumed strategy for immediate free recall (when the basic traces are laid down).

Further, as noted previously, the recency retrieval strategy models of Bjork and Whitten (1974) and Baddeley and Hitch (1977) would not expect any such finding in final recall where the unit for retrieval is unlikely to be individual terminal items.

Baddeley (1976) offered one other ingenious explanation of the negative recency finding based on the research on massed versus distributed practice. He argued that during immediate recall, terminal items are presented and recalled in quick succession (an example of massed practice) while early list items are only recalled after a number of intervening events (distributed practice). Given the well established finding that the further apart the learning trials the better the performance (eg Melton 1970), good long-term retention is predicted for early items and only poor retention for later items. However, the only way in which this type of explanation could conceivably have resolved the issue would have been if Experiment 10 (where the lists were longer) had exhibited negative recency in both list conditions. As with the other models considered, this account cannot cope with the asymmetric effects.

At this point the exercise of attempting to provide a satisfactory theoretical account for these findings will be terminated. Clearly efforts could be made to construct some model to fit the effects but the result would be likely to be so complicated as to be of little general value.

They may well reflect the effects of rate; the encoding context; and differences in the effectiveness of retrieval cues, but the interactions would appear to be far from straightforward. In any case it is not clear whether the findings represent a genuine set of effects, given their size and apparent inconsistencies. Suffice it to say that prediction and explanation of such effects would appear to be extremely difficult. Attention will therefore be turned to the second major reason for conducting the experiments - the examination of the final recall data as a function of input lists.

5:5:4 Final Recall - Lists

The results of both Experiment 9 and 10 offer convincing evidence that the final recall of lists presented during a standard free recall session conforms to a very regular pattern. The function appears to be determined by the position occupied by each list in the input sequence, with later lists being recalled best of all, and performance gradually deteriorating for lists further from the point of recall. These findings therefore confirm results reported by Murdock (1972) and Bjork and Whitten (1974) plus the suggestive evidence of the previous chapter, although they go further than all of these results in a number of important respects. Before going on to address these issues in detail it is necessary to offer some comments and comparisons between these recency phenomena and more conventional examples in the literature.

(i) Recency Phenomena and Questions of Measurements : Certain criticisms can be advanced against a position which seeks to equate the above results with other forms of recency noted, quite apart from considerations of the mechanism(s) responsible. One of the most obvious of these would be that while the functions obtained for terminal lists resemble those obtained for individual items (eg in immediate free recall, or in running memory span) at least in basic form, the levels of performance attained in these different situations is far from equivalent. Typically the scores for list recency falls considerably below that for individual items. For example, recall of the last item in a typical immediate test would be likely to be of the order of 90+%, while recall of the last list in any of the present experiments rarely exceeds 60%. However, one important aspect of the two situations should be borne in mind : namely what is being measured in each case. Thus an item is either recalled or it is not, and by conventional scoring methods in free recall, the appropriate item would require to be recalled before credit is given. On the other hand it is always likely that only a certain proportion of a list is recalled (assuming lists above span size are employed). The point is

illustrated by noting that even under conditions of immediate recall, no subject in the present experiments achieved a perfect list recall. Thus with large and complex units one is always likely to be dealing with proportions of the total possible, even under ideal conditions, while with individual items in conventional short-term memory tasks, scoring is typically all or none. In this context it is instructive to refer to the work on the 'tip of the tongue phenomenon' (Brown and McNeill 1965) where part-recall of individual items is utilised, but only because the experimental method and scoring procedure permit. The point which is being made therefore is that different absolute levels of performance are to be expected when comparing different sets of stimuli where the scoring method permits divisibility of one type, but not of another. Such differences however should not be taken as proof that fundamentally different processes are being compared in the situations under examination; the fundamental principle underlying recency phenomena is that the closer the unit being measured is to the point of testing, the higher its recall is likely to be.

(ii) The Nature of the List Effects : Several features of the data should be noted prior to discussion of the theoretical implications. In the first place, the recency effects obtained with this scoring procedure are substantial (when compared for example against the individual item effects discussed above), and extend backwards through all the lists in the input series in an orderly fashion. Both experiments testify to this reliability.

In the second place, unprompted final recall indicates that the list material is of secondary importance when compared to the ordinal position the list occupies within the series. Later lists were always recalled substantially better than earlier ones regardless of whether the material was unrelated or categorised (Experiment 9) or whether the semantic material was arranged in homogeneous or mixed formats (Experiments 9 and 10). This is important because it appears to stress the fundamental importance of list-processing for immediate recall as the basis for laying down the relevant trace. Thus under mixed list conditions for example the subject has to process each list for immediate recall, and presumably in some fairly unique way in order to differentiate it from all previous lists. This organisation clearly forms a basis for the subsequent recency effect, subject only to the further constraint of how close to the end of the series the list is. The same is presumably the case for lists of unrelated items.

A further important aspect concerns the cued final recall data of Experiment 10 : clearly category cueing can be effective in the final recall of semantic material once again emphasising retrieval limitations and

problems of accessibility (cf Tulving and Pearlstone 1966). Further, the particular form that such a benefit will assume will depend crucially upon the presentation format of the lists. Where lists and categories are equated in a one to one relationship, the recency effect for lists could merely reflect the category recency effect obtained in Experiment 8 of the previous chapter. Thus the relatively poor recall of earlier lists can be elevated substantially by the provision of the unique semantic cue necessary to access these lists. The situation is different for the mixed list conditions where category organisation does not equate with list organisation. Under these circumstances cueing clearly does raise overall performance by providing access to 'lost' categories, but the effect is fairly evenly distributed across all input lists. The prime determinant of the recency effect remains the idiosyncratic organisation afforded each list during acquisition, and how this survives till the final recall phase, with later lists still producing better performance than earlier ones.

A number of important theoretical consequences follow from these findings. These will now be dealt with.

(iii) Theoretical Implications : The experimental conditions prevailing during final free recall paradigms permit the immediate rejection of certain theoretical accounts of recency as providing adequate bases for the list-recency effects described above. In the first place, as final recall is unanticipated it can be assumed that no list received any further processing following its immediate recall test. This rules out all explanations based on mechanisms which involve processes of 'conscious awareness', active rehearsal operations, or short-term stores (eg Waugh and Norman 1965; Atkinson and Shiffrin 1968; Glanzer 1972); the lists are clearly not still being attended to after recall of the last list is completed. Thus versions of the modal model have difficulty in coming to terms with the effects.

In a similar fashion a levels approach (Craik and Lockhart 1972) would not appear to effect a satisfactory account, as recency effects are assumed to reflect relatively short-lived phonemic traces. The above effects are clearly not 'short-lived' in the same sense, and further, show definite evidence of semantic encoding. Even on the issue of Type II processing (Craik and Lockhart 1972) or elaboration encoding (Craik and Tulving 1975) there would appear to be nothing in the formulation which directly address the findings noted above i.e. where later lists are better recalled but where all lists can be assumed to have been processed in a similar fashion.

Thus for both major theoretical accounts the problems of explaining the above effects seem formidable. Their concentration on the vulnerability of immediate free recall recency and their apparent lack of attention to aspects of longer-term retrieval make it difficult for them to come to terms with serial position effects spanning a much greater time-frame.

The results however do not provide the same embarrassment for the other class of models designed specifically to handle recency phenomena (Bjork and Whitten 1974; Craik and Jacoby 1975; Baddeley and Hitch 1977). The implied operation of a retrieval strategy which can be applied to any set of items, or units, which are considered appropriate proximal events at the time of testing offers a reasonable description of the data. Furthermore while the retrievability of such units could be on a basis of uniqueness by categories (where this applies as in the category recency effect of Experiment 8, or the homogeneous lists of Experiments 9 and 10) this need not be the case. Clearly the organisation devoted to any list for immediate recall provides an adequate basis for the effect. On the other hand, under the appropriate conditions, the provision of a unique cue during recall which guarantees access to all list items, appears to overcome the ordinal effect of input list position. This further suggests that storage factors per se are not the crucial determinant of all such effects; adequate description can therefore only be attained by implicating retrieval processes, and how these appear to be 'recency sensitive'. All three of the models considered would appear to satisfy these requirements although clearly the primary memory option of Craik and Jacoby (1975) is not involved in the production of these effects.

. At this stage it should be noted that several questions which could be posed, are not directly addressed by the experiments reported. In the first place, it is not known to what extent output interference can influence the list-recency effects. It will be recalled that this factor could be shown to affect the category-recency result described in Chapter 4. An experiment similar to Experiment 8 employing particular output instructions would be required to settle this issue more conclusively with regard to the present findings. Secondly, there was no attempt to vary the temporal distance of the final recall test from the list learning phase. Thus while the evidence advanced thus far implicates a recency-sensitive process which could prove to be less efficient or appropriate as the relative separation of the lists decreases, and the time to final recall increases, (cf Crowder's 1976 analogy of telegraph poles where very little space exists between different groups and a large distance separates the last group from the point of viewing), a direct test would require to be mounted to settle the issue. In this context, Bjork and Whitten (1974)

present some tentative evidence which does suggest that list-recency can be eliminated by a 24 hour delay before final recall testing. Clearly careful tests of this nature would provide a fruitful line for future enquiry. In particular, they might help to differentiate between theories which appear to stress merely the ordinal aspects of a temporally-organised series (Baddeley 1976; Baddeley and Hitch 1977), and those which emphasise the relative temporal relationships when viewed from the point of recall (Bjork and Whitten 1974).

Two experiments were described comparing the immediate and final free recall of lists containing different types of stimulus material. In one study (Experiment 9) each list contained either items from only one category (the homogeneous condition); single examples from all the categories employed (mixed conditions); or totally unrelated items (control condition). In Experiment 10, only the two category conditions were re-employed, and presentation rate, list length, and the number of lists were altered. The main results and conclusions are summarised below.

(i) Effects on Individual Items: Under conditions of immediate recall all lists exhibited standard free recall functions with both primacy and recency components. In agreement with other research, homogeneous lists produced the best performance, and this effect was restricted to pre-recency portions provided adequate controls were applied. Under conditions of final recall, homogeneous items maintained their superiority, but a variety of inconsistent effects were observed across terminal items for all list conditions. All the major theories appeared supported by the former findings, but no model could be found to account for the latter results. It was suggested that negative recency is not a reliable phenomenon, and that the effects obtained probably reflect a complex interaction of rate; the encoding and immediate recall contexts; and the value of retrieval cues. It was concluded however that these effects are of a somewhat trivial nature compared to other findings in the data.

(ii) Effects on Lists: The most important finding to emerge from both experiments was a substantial and reliable list-recency effect to be found in final recall. Under unprompted recall conditions this effect appeared to be independent of list material and subject only to the position occupied by each list within the input series. Experiment 10 went on to show that category cueing was an effective technique in FFR and resulted in the raising of performance by a relatively constant amount across all lists in the mixed condition, and by selectively raising early list performance in the homogeneous condition. This result not only pointed to the relative value of appropriate cues, but also stressed the retrieval aspects of the processes involved. Neither of the two major theoretical positions was deemed to have a satisfactory explanation of these serial position effects, and it was concluded that theories stressing recency-sensitive retrieval processes operating on organised series were favoured by the data.

CHAPTER 6

GENERAL SUMMARY OF MAIN FINDINGS,

THEORETICAL IMPLICATIONS, AND FINAL CONCLUSIONS

6 : 1	PREFACE
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	6:2:1 Unitary versus Multiple Models
	6:2:2 Evidence for a Mechanism of Conscious Awareness
	6:2:3 Evidence for the Operation of a Retrieval Strategy
	6:2:4 Conclusions on Recency
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	6:3:1 Single versus Dual Explanations
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	6:3:3 Evidence for Primacy Salience
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6 : 4	CONCLUSIONS ON THE MODELS EXAMINED
6 : 5	SUMMARY OF FINAL CONCLUSIONS

The focus of this investigation has been the study of particular phenomena exhibited in short-term memory tasks and the processes they represent, especially in so far as these can be inferred from serial position analysis. In this context, effects which pertain to the beginning (primacy), and end (recency), of a set of stimuli have been examined; although particular attention has been devoted to recency because of its central role in current theoretical debate. This in turn has necessitated the use of a variety of experimental paradigms in an effort to provide the fullest possible picture of the effects.

It is now necessary to survey, in summary form, the results of the research conducted in an effort to draw final conclusions regarding theoretical implications. In this last chapter, therefore, three inter-related key questions will be addressed :

(i) Whether a unitary view of recency is tenable, or whether a multiple model offers a more complete description of the findings;

(ii) Whether primacy is the product of one or more processes;

(iii) On the basis of the above, whether any current theory can encompass all the findings adequately.

6:2:1 Unitary versus Multiple Models

It is clear that the findings which cause most of the problems for the models entertained in this investigation are those of recency. Original focus on this phenomenon during the research of the 1960's was concentrated primarily on the basic form of the free recall task, and to a much lesser extent the serial probe paradigm. However, the research reported here, in conjunction with other evidence now in the literature, quite clearly shows that recency is a much more ubiquitous finding than this early work suggested. For example, not only is it a feature of other tasks as diverse as recall performance in running memory span (Pollock, Johnson and Knaff 1959) and reaction time measures to homonym and synonym targets (Shulman 1970), but also as the present results have demonstrated, several recency effects can be shown to co-exist within the free recall task itself, provided that the appropriate units are scored. It is precisely because of this growing variety of recency findings that it is now necessary to consider whether only one mechanism can be held responsible for all examples of the effect.

On this point it will be argued that, at the present time, some form of multiple model of recency determination provides a more adequate description of the data than does a unitary view. The basis for this position is amplified below. In essence, the argument to be adopted states that recency could be the product of at least two processes. The first of these is reflected by the output of a number of items which, it can be assumed, were being held in some 'active state' at the time of recall. Evidence for the second process comes from the finding of recency effects in other task situations, where, by nature of the prevailing conditions, the first possibility is precluded.

6:2:2 Evidence for a Mechanism of Conscious Awareness

As noted in Chapter 1, one of the principal foundations of the modal model in all its forms was the existence of a mechanism capable of holding only a few items, and which was extremely vulnerable to interpolated activity. At various times this has been referred to as primary memory (Waugh and Norman 1965), the short-term store (Atkinson and Shiffrin 1968; Glanzer 1972) or a rehearsal buffer (Atkinson and Shiffrin 1968). Although other findings could be drawn upon to support this claim, the prime source of empirical evidence for such a system

was taken as being the recency effect in free recall (eg Glanzer and Cunitz 1966). This view has been challenged subsequently by numerous other results, including many from the present investigation, which have demonstrated similar effects in situations where such a mechanism cannot possibly be held responsible. Indeed, as also noted previously, there was other evidence available which suggested that the original statement regarding the early free recall findings was highly suspect. For example, the data of Rundus (1971) carried with it the implication that the terminal items which make up the recency effect were not all being held in a state of conscious awareness at the time of recall, but rather, that a majority of earlier items were being attended to. A somewhat similar conclusion has been reached by Bernbach (1975).

However, while the combined weight of this evidence argues against any single account of recency which is based upon a short-term holding mechanism, this should not be taken as ruling out the possibility that such a system could be involved in the production of particular recency effects. Stated another way, to demonstrate that an explanation does not fit all possible experimental situations does not eliminate it as a theoretical contender, it merely implies a limit upon its generality. Even the fact that the original account was possibly erroneous (or at best overstated) with regard to typical free recall is not as damaging as it at first appears. This is because there is now additional evidence on recency effects from other sources which directly implicates a system which is concerned with actively maintaining a set of items in current awareness. The most convincing example of this within the present investigation comes from the studies on running memory span (Chapter 2).

The results of the running memory span experiments are unambiguous in the sense that they are not open to the criticisms which can be levelled at the free recall task. In particular Experiment 2, which directly manipulated processing strategies during input shows that subjects can successfully employ methods of group rehearsal, and further that the recency effects obtained under these conditions can be viewed as the natural consequences of offloading these groups at the time of recall. In addition it is clear that such a strategy is both the preferred mode in this task, and indeed produces superior recall to any acquisition method which merely involves attention to individual items. The results of the grouping strategy subjects noted above therefore appear to offer unequivocal evidence of recency which is the product of some rehearsal/processing mechanism geared to maintain several items together in conscious awareness.

A similar conclusion can be drawn from the studies by Craik and Watkins (1973) and Shallice (1975) where subjects processing free recall lists were instructed to pay particular attention to terminal items. In these cases the more abrupt shape of the function can be explained by the fact that the critical items were objectively cued during presentation. This would ensure that all subjects began processing the terminal set at the same point - something which could not be guaranteed in the running span lists, where an altogether smoother function^{obtains}/. However these results again demonstrate the output of some form of holding mechanism in a way which maximises primary memory in recency.

Finally in this section one can include the continuous paired-associate task cited by Atkinson and Shiffrin (1968) which inspired their rehearsal buffer model. Although certain differences between this and the running span paradigm have been noted, there is still a degree of overlap in the basic nature of the tasks and therefore, one assumes, in the underlying mechanism. To the extent that they converge, it is hardly surprising that their model provides a good fit to the paired associate task and a reasonable description of the running span data.

In summary therefore, there is definite evidence that recency effects can reflect the output of some active processing mechanism. The necessary preconditions for this to occur would appear to be situations where task demands or task requirements result in a strategy of processing only relatively recent information. Under such circumstances attention will only be devoted to terminal items at the time recall is demanded. The most obvious case where this would be likely to occur naturally would be tasks where some form of continuous updating is required and where the lists are not of fixed length, although clearly the result can be obtained where other means are employed to induce optimum immediate recall of terminal items (eg Shallice 1975).

Two final comments on the mechanism responsible are appropriate at this stage. Firstly, although the labelling of the 'primary-memory-type' system implicated in the above results is fairly arbitrary, it should be noted that the present argument stresses an active processing cum rehearsal function. The system is not therefore responding like a passive receiver. Such a view which virtually equates items in conscious awareness with a rehearsal loop is not novel. On the basis of other evidence which suggests a reciprocal relationship between rehearsal and interpolated activity Crowder (1976 p.196) makes much the same point. Secondly, and as a consequence of the former point, this explanation

marks a shift in emphasis from the concept of a storage space with a fixed capacity, to one which refers to a process. The effects of presentation rate on running span performance reinforce this interpretation, and indicate one crucial way in which such a process is limited.

Finally, while this discussion has tended towards suggesting the operation of some form of 'working memory' of the type proposed by Baddeley and Hitch (1974) it is not clear whether only the rehearsal loop of such a system is implicated in the above results. Further research would be necessary to establish this point. Whatever the case, however, this would still represent a departure from the Baddeley and Hitch (1974) position, in that they do not consider any part of their general system as being responsible for recency effects, whereas this account directly links the two.

6:2:3 Evidence for the Operation of a Retrieval Strategy

The mechanism defined in the preceding section clearly only accounts for particular cases of the recency effect. There is now abundant evidence of similar effects which lie beyond the scope of any rehearsal/primary memory system. Three crucial findings from the present investigation can be cited as examples of this latter category of recency effects.

Firstly, in the running memory span task, even when processing is devoted only to the current item presented, there is still evidence of recency in the data (Experiment 2; Single-item strategy condition). Performance gradually deteriorates the further items are from the end of the list. These functions show evidence of a more linear decline than do the corresponding curves for the grouping condition. Indeed it is as if the output from the rehearsal loop (grouping condition) had been 'peeled off' to reveal a secondary recency finding underneath.

Secondly, it is difficult to imagine the rehearsal (PM) mechanism being responsible for the category-block recency effects of Experiments 7 and 8. The principal reason for this is because such a mechanism is assumed to be engaged in recirculating the category members themselves at that time.

And finally, there are the list-recency effects of Experiments 9 and 10. Because of the conditions prevailing in these experiments, where the final recall test was unanticipated, there is no reason to suppose that any rehearsal across lists took place. Therefore, no system based on a concept of conscious awareness could be invoked to explain such findings. Also, Experiment 10 demonstrated that the provision of

appropriate cues (where these exist and can be identified) can alter the recency effects obtained. While this does not deny the importance of storage factors, it clearly places emphasis on the retrieval aspects involved in the process responsible.

When these findings are drawn together with other results in the literature (eg the so-called 'long-term' recency of Tzeng 1973; Bjork and Whitten 1974; and the incidental learning task recency noted by Baddeley and Hitch 1977) it soon becomes clear that an account based on any type of primary memory mechanism is inadmissible. Quite apart from considerations of time-scale, and the size of the units involved, the effects evidently occur at the retrieval phase i.e. when processing has ceased. Partly because of this however, it is still possible to encompass all the apparently diverse findings in this second category of recency effects within a single theoretical framework. This is achieved by appealing to some form of ordinal retrieval strategy which can be applied to recent events at the time of recall. The crucial aspect of this explanation hinges on the definition of a 'stimulus event'. Given that the above findings reflect retrieval processes, the relevant units upon which such a process can operate, are defined by that dimension which is most appropriate to the strategy when viewed from the time of the recall test. In this respect the choice of dimension is bound to reflect the organisation imposed upon the material during input.

The situation is well illustrated by Crowder's (1976) spatial analogy of looking back at a series of telegraph poles, or groups of poles. Recency retrieval can be directed at the most salient aspect of the organisation of the series as it appears from the current viewpoint. Thus in the case of the immediate recall of a list containing single items, retrieval can be directed firstly at the terminal items. As this procedure produces diminishing returns due to intervening items, at some point the strategy will be abandoned in favour of one which makes use of other organisational features imposed upon the list during learning (eg the way in which the primacy portion was processed). In the absence of this latter opportunity, for example as is the case in running memory span or incidental learning tasks, the recency retrieval strategy will be pursued exhaustively, until only guessing behaviour is possible. In the immediate recall of lists containing groups of related items, recency retrieval can once again be directed at the terminal items. However the organisation of the input also provides a second opportunity to employ the strategy - this time upon the category blocks themselves. Under conditions of final recall, neither individual items, nor category blocks provide an appropriate dimension as too many similar units have

intervened. In this situation the input lists themselves offer the salient organisational feature.

Such an account appears to offer the best description of all recency effects noted in this section. Moreover it carries with it one important implication: Namely that as far as these phenomena are concerned, the original distinction between short-term (immediate) and long-term (delayed) recall is no longer useful, or indeed appropriate. Thus the emphasis shifts to becoming one of 'relative' organisational and temporal aspects of the input series where these are defined from the standpoint of the recall test. Fruitful lines of enquiry for future research therefore require to take cognizance of this fact.

For example, the category-block recency effect could be considered 'relatively short-term' in the sense that it did not appear in final recall where it was superceded by the more appropriate list recency. However, the above model implies that list recency itself could be eliminated given suitable conditions. Although the author has no direct evidence of this from the present investigation, it is instructive to note that Bjork and Whitten (1974) present tentative evidence of just such an effect under conditions of a 24 hour delay test.

It must be acknowledged that, at this stage, equation of the category-block recency effect with the list recency effect may be premature. As indicated in Chapter 5 more detailed work on the consideration of output interference, and controlled manipulation of the temporal distance of the recall test from the learned series, is indicated before this statement can be made with total confidence. For the moment however, and in the interests of parsimony, there would appear to be good grounds for assuming that these effects are two examples of the same process. As presented here the recency effects described in this section are compatible with the models offered by Bjork and Whitten (1974), Craik and Jacoby (1975), and Baddeley and Hitch (1977).

6:2:4 Conclusions on Recency

The arguments advanced in the foregoing sections present the case for recency both being the product of some active rehearsal or primary memory type mechanism, and the result of an ordinal retrieval strategy, (although the latter would appear to handle more of the effects discussed). Under these circumstances, therefore, the only way in which a unitary view of recency is still tenable is to maintain that it represents the operation of a control process which maximises recall of

proximal units. If these are resident within some recirculatory system then they can be output, if not, then some form of serial backward scanning retrieval process can be adopted. Thus a detailed description of the findings presented can only be secured by appealing to at least two processes. This statement has immediate theoretical implications: Only one of the models under consideration (Craik and Jacoby 1975) can provide an adequate description of all the results.

While the rehearsal buffer model of Atkinson and Shiffrin (1968) has obvious similarities with the active processor processed above, the model is probably not the best account of all free recall recency, and is totally unable to cope with the second category of recency effects. Also, although a levels of processing account (Craik and Lockhart 1972; Craik and Tulving 1975) appears to make use of a PM mechanism, it has grave difficulties with predicting complex recency effects, especially those involving semantic processing. Of the final class of model examined both the Bjork and Whitten (1974) and Baddeley (1976 ; Baddeley and Hitch 1974; 1977) positions offer similar and reasonable accounts of the findings which suggest a retrieval strategy view of recency. Both, however, as currently formulated offer only a unitary view of the phenomenon. Of the two, it is arguable that the Baddeley and Hitch (1974; 1977) account would require the least damaging modifications. This would entail (i) a specific statement to the effect that the rehearsal loop component of their general working memory model (Baddeley and Hitch 1974) could be offloaded to produce recency under circumstances where it was recirculating the terminal items at the time recall was demanded; and (ii) a lifting of the constraint placed on recency effects for items which are semantically related.

As suggested in Chapter 5, other work may also be required to resolve any subtle differences between a purely 'ordinal' view which stresses only that the stimuli represent an ordered series, and a position which emphasises the relative temporal relationships thus highlighting the interval separating the events, and that between the last event and the recall test.

These comments apart, as things stand, only the multiple model of recency proposed by Craik and Jacoby (1975) would appear capable of handling all the recency findings with relative ease. Further evidence would probably be required to evaluate fully whether their third stage - the guided reconstruction process - is really necessary, although the cued final recall data of Experiment 10 offered some tentative evidence in its favour. One other feature of the results

should be emphasised in connection with this type of model. Although Craik and Jacoby (1975) do not make explicit reference to the fact, it is clear that subjects can opt to use more than one process, or even the same process twice (provided it is not the PM mechanism) in the context of the same organised series of stimuli. The co-existence of terminal item recency and category-block recency noted in Experiment 8 bears witness to this conclusion. Thus the various operations need not be considered mutually exclusive, although probably more data would be required to establish an accurate mapping of their interactions.

Thus while certain details concerning the operation of the particular processes may require refinement in the future, the Craik and Jacoby (1975) account of recency effects is considered to be the most adequate framework at present, as it alone recognises the need to appeal to more than one process.

6:3:1 Single versus Dual Explanations

Although the main focus of this research has centred on the topic of recency, considerations of primacy cannot be ignored totally, especially as they too bear on the major theoretical accounts being examined. Up until now the most commonly accepted view of primacy has been that it derives from the initial items receiving more rehearsals than later items (eg Atkinson and Shiffrin 1968; Bruce and Papay 1970). The position to be advanced here accepts that this is probably correct for most of the situations under which primacy occurs. However it is argued that certain pieces of evidence suggest that there may be some inherent salience attaching to the beginning of a set of stimuli which could also give rise to primacy effects in the absence of differential rehearsal. There are two principal sources of primacy in the present investigation which merit close attention in the light of these issues. The first concerns the within-list primacy effects obtained in all experiments where groups of related items were presented in blocks during input (Experiments 5, 6, 7 and 8). The second derives from the particular primacy facilitation effects described in Chapter 3 (Experiments 3 and 4).

6:3:2 Evidence for Differential Rehearsal

Evidence presented in Chapter 4 demonstrates that primacy is not the sole preserve of the beginning of a memory list. However, as noted previously the within-list primacy effects in the blocked-category experiments are compatible with an explanation based on differential rehearsal. Indeed this seems the most likely explanation considering the data of Rundus (1971). His studies provide strong evidence that the inclusion of related items in a list results in a processing strategy whereby these items are rehearsed together. It is therefore plausible to assume that where such items are presented in groups, the rehearsal pattern typically adopted for whole lists (Rundus and Atkinson 1970) becomes the norm for each category block.

As reported earlier, such an account is predicted by versions of the modal model - especially that proposed by Atkinson and Shiffrin (1968). A levels of processing account however assumes that primacy is the

product of Type II (semantic) processing. Owing to a lack of detail in the model, it is not clear whether the theory actually predicts these within-list serial position effects, as it would be required to assume that the subject continually switches from Type II to Type I processing and back again during presentation. Nor would notions of elaboration encoding (Craik and Tulving 1975) appear to be any more specific on this issue. Finally, and alternatively, if the theory is forced to account for these findings by resorting to differential rehearsal, it would not appear to offer a radical departure from versions of the Modal model.

6:3:3 Evidence for Primacy Salience

In contrast to the foregoing section, the evidence presented in Chapter 2 appears to offer some consolation to a view which admits to a special degree of salience attaching to the initial items in a sequence. Further work is probably required on this phenomenon, but the fact that the primacy portion of a memory string is enhanced by the presence of an identical pre- or post-distractor list (which does not have to be memorised), is strongly suggestive of such an account. Of the two studies reported, Experiment 2 provides the weaker evidence to support such a conclusion. In this study, as the memory list is processed first, the delay list could conceivably have been recognised as being identical, and this in turn would be more likely to be the case for the initial items (because they were better rehearsed in the memory list). This recognition process therefore could serve as 'further processing' of these items, thus leading to their enhanced recall when compared with controls. Such an explanation however is less credible for occasions when the 'distractor' precedes the memory string (Experiment 4). In these circumstances, as there is no requirement to memorise the distractor material the items are unlikely to have received any additional processing beyond the classification decision. No account based on differential rehearsal could therefore be invoked to explain the apparent durability of the initial items in the distractor list when the memory list begins. Nevertheless, primacy of the memory string is enhanced under such circumstances; a fact which testifies to the survival of the initial items of the irrelevant list. The simplest explanation of such a result is to assume that the initial portion of any series of stimuli attended to - whether they are to be memorised or not - is somehow

awarded a privileged status which can render it more memorable than later events in the same series.

Finally it can be noted that further evidence supporting such a conclusion comes from the studies by Tzeng (1973) and Bjork and Whitten (1974) both of which demonstrated primacy effects under conditions of inter-item distractor activity which should have eliminated differential rehearsal. Even more impressive perhaps is the discovery of primacy in incidental learning tasks where subjects are given an unexpected recall test at the end of the session (Baddeley and Hitch 1977). As subjects do not anticipate the memory task, there is no reason to suppose that the items were treated in anything other than a discrete fashion. Once again therefore no appeal can be made to differential rehearsal of the initial items to explain the findings.

While a levels of processing framework (Craik and Lockhart 1972; Craik and Tulving 1975) admits that any item which is attended to will leave some form of trace, regardless of whether or not it had to be memorised, the restricted locus of the effect under discussion is an embarrassment to the theory. By definition, primacy effects require to be the result of Type II processing. As the essence of the argument here is that primacy can occur in the absence of such special encoding operations, the model is rendered unsatisfactory. In this context it is ironic to note that the incidental learning paradigm, from which the theory sought to draw so much early support, is now partly responsible for its refutation. Likewise versions of the modal model would appear to be inadequate as they can be reduced to explanations based on differential rehearsal. This would appear to leave a modified version of the positional distinctiveness hypothesis as the only explanation of these effects. Earlier such an account was dismissed as a general theory of all serial position effects because (a) it did not appear to integrate well with other known facts concerning storage and retrieval, and (b) it did not appear capable of handling the asymmetric effects obtained in the current investigation (i.e. primacy in the absence of recency and vice versa). However, in order to account for the effects described above, it would now appear necessary to resurrect at least that part of the theory concerned with primacy. In the absence of more definitive evidence it must be admitted that the precise nature of this process is not fully understood. It could for example reflect some perceptual process which results from a state of 'preparedness to receive' a set of stimuli (cf Hamilton, Hockey and Rejman 1977). On the other hand it might simply reflect a retrieval operation which can make use of 'anchor features' within a series when such are available

(eg Roediger and Crowder 1976). At this stage however such accounts would require to be fairly speculative, and for the moment at least, the model must remain more of a description than an explanation of the effects.

6:3:4 Conclusions on Primacy

Thus as with recency, it appears that satisfactory accounts of primacy effects are only possible if more than one process is assumed responsible. On most occasions an explanation based on differential rehearsal and the operation of a Working Memory System would appear to be appropriate. On the other hand the discovery of primacy effects in the absence of such strategies demands that a concept of salience for the initial items in a series of stimuli is retained. For the moment, however, the precise nature of this second process must remain obscure.

The first point which can be made in this section is that, quite clearly, no single model out of those under consideration in the opening chapter, is supported by all the findings presented. While this is obviously going to be the case for theories which have been constructed solely to explain particular effects (eg the recency-only models), the same comment can be made with equal conviction of the general theories reviewed. The discussion sections of each of the experimental chapters, and the summaries on recency and primacy just presented bear witness to this fact by offering some comfort to the various models in turn, but to none consistently. These arguments need not be restated here.

The most obvious conclusion which can be drawn from all of this is that the success or failure of any of the theoretical positions considered appears to be dependent upon the paradigm being employed, and even upon the particular experimental conditions operating in different versions of the same paradigm. (Hence, for example, the modal model offered very accurate prediction of the results of the early blocked-category studies - Experiments 5 and 6 - but was not supported by later work with the same material which show recency effects for category blocks and even for lists - Experiment 8). Such a situation must be considered particularly damning to any thesis which purports to offer a general statement of memory system function. The major criticisms pertaining to the theories examined can be summarised briefly as follows :

(i) The Modal Model: Of the two main theoretical positions examined variants of the modal model provided the most detailed accounts. This was especially true of the version proposed by Atkinson and Shiffrin (1968). While this tended to facilitate the forming of detailed prediction concerning serial position effects, it was precisely this specificity which led to the model's refutation on occasions. In the main these came about in the experiments which demonstrated recency effects beyond the capacity and time-scale of operation of any short-term or rehearsal mechanism.

(ii) Levels of Processing: On the other hand, a levels account in an attempt to provide a more general framework, appeared to lack the necessary precision to enable specific predictions to be made. This was especially true with regard to serial position effects. In this context, the omission of any adequate taxonomy of encoding operations; the lack of an independent index of depth (cf Chapter 3); and the

inability to address possible differences existing within any one processing domain (especially the semantic) appeared particularly serious limitations. As with the modal model, this theory found major difficulties were faced with recency phenomena. Furthermore, on most occasions where the theory was successful in accounting for the results, it was not readily differentiated from versions of the modal model it claims to supercede. Similar remarks have been made by Postman (1975) and in a recent review article by Baddeley (1978), and are borne out by much of the research presented here. Some of these problems would seem to highlight the dangers inherent in approaches which seek to produce a very general framework, and avoid detailed consideration of specific processes for fear of becoming too mechanistic.

(iii) Other Models: Of the specific models examined to account for particular effects, the recency-only theories of Bjork and Whitten (1974) and Baddeley and Hitch (1977) appeared to offer more suitable explanations of the growing number of recency phenomena now being discovered, than either of the two major positions. However, as currently formulated, these models themselves were considered inadequate to encompass all the findings which could be cited. On this basis therefore only the multiple model of Craik and Jacoby (1975) appeared to offer a satisfactory option by appealing to more than one process as underlying recency effects.

Finally it is necessary to include some reference to the positional distinctiveness hypothesis. While this account claims to offer a general theory of serial position effects, this was not borne out by the evidence. It is included in this section dealing with theories of specific effects however, because there appears to be sufficient evidence of primacy effects occurring in the absence of deliberate organisational processing. Almost by default therefore, that part of the theory dealing with the initial portion of any defined set of stimuli requires retention.

The research reported here has not sought to develop a novel theory of short-term memory function. Rather the approach has been to conduct a series of critical experiments with the intention of evaluating the major classes of model which already exist within the literature. In this context, specific reference has been made to how the various theories account for the particular serial position effects of recency and primacy. On the basis of the evidence reported the following conclusions can be drawn.

(i) Unitary accounts of recency are inadequate; at least two processes require to be postulated to encompass the findings presented. One of these represents an active processor, probably a rehearsal mechanism, which can offload those items currently held within conscious awareness at the time of recall. The other is best described by the operation of a retrieval strategy applied to terminal items, or appropriate proximal groups of organised items. Only one theory currently formulated (Craik and Jacoby 1975) recognises the need for more than one mechanism in accounting for recency phenomena.

(ii) Similarly, a full description of primacy can only be achieved by appealing to a dual basis for the effect. While the majority of primacy effects may be explicable in terms of the differential encoding operations normally afforded initial items in a series, it is still found to be necessary to preserve a concept of 'primacy salience' to explain effects which occur in the absence of such strategies, although the details of this latter process are not fully understood. No current theory encompasses both these notions.

(iii) On the basis of the above it can be stated that no model currently proposed - including those which purport to be general theories - can account for all the effects presented. The best fit to the data could only be obtained by an amalgam of various attributes of several different models.

(iv) Finally, and as a particular consequence of the recency effects obtained (cf (i) above), the concept of short- versus long-term appears to be no longer viable. A shift of emphasis towards consideration of the 'relative' organisational and temporal aspects of the input series would seem to be required, where these are defined from the point of the recall test. Future research and modelling exercises should therefore take cognizance of this fact.

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