SERIAL POSITION EFFECTS

IN LONG-TERM MEMORY TASKS

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Amancio Pinto

PREFACE

When this research project came to an end, I felt a sense of relief and also some dissatisfaction. Relief, since I accomplished this dissertation in approximately three years, so I have not wasted the money that my sponsors invested on me. Dissatisfaction, because I had to abandon earlier than I expected the idea of running more experiments for reasons of limited time.

If I were not under enormous time pressure, I certainly would have run another experiment on ageing and one or two more on the effects of order in long-term recency, thus clarifying the conclusions drawn from the research carried out in chapters six and seven. However, there comes a time when one must decide where to stop experimenting and start writing, and this dissertation is the result of such a decision. When I made up my mind, I was aware that other investigators sometimes confess similar feelings and express them in such ways as "more research is needed", "this is a progress report", or "future experiments should clarify the matter". I should like to say the same.

Among other good things, writing a PhD in Cambridge means that almost every paper published in English is at hand. Thus, and in contrast to some postgraduate students, I enjoyed the time spent on writing the theoretical chapters as much as the experimental work I did. The only problem that arose was to decide which papers were relevant to be quoted in this

dissertation. I confess that I certainly have not looked at more than 75% of the literature which in one way or another could have been related to this research. Yet the papers quoted were no more than one third of the sample I have read and even so the number selected was about 240. This number represents a serious attempt to restrict the references to the leading investigators and to recent papers published in the main journals of psychology.

The result of this literature search is the first five chapters. If I had more time I would reduce rather than increase the number of written pages. I became aware with some surprise that it is much easier to write more than less pages. Despite that, I took pains to write as clearly and concisely as possible in a language that will never be mastered as proficiently as my mother tongue.

Finally, special care was taken to use abbreviations with moderation and to restrict their use to one or two pages. In any case, a list of all abbreviations used and its correspondent meaning is included in the Appendix. Whenever possible I tried to comply with the style recommended by the Publication Manual of the American Psychological Association (1983), especially in relation to references, quotations, Tables and Figures.

At last minute, it was suggested that I should include the Anova tables. Since it was impossible to include all of them (about 60) I selected only the Anova tables that were related to the major findings of each experiment. They are presented in the last five pages of the Appendix.

Acknowledgments:

First of all, I should like to gratefully acknowledge the generous contribution of my supervisor, Dr. Alan Baddeley. I would like to thank him for providing me with working facilities at the APU, for his guidance, for his idea and suggestions on the design of the parking experiments, and for his thoughtful criticisms of an earlier draft of this dissertation.

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I should like to thank the Medical Research Council for allowing me to use the facilities at the Applied Psychology Unit.

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I should like to thank Dr. Arnold Wilkins for his help at an early stage, Dr. Ian Nimmo-Smith for his statistical advice at all stages, and Mr. Steve Platt, the computer manager, for his help with the PDP 11/60 computer, which was used for data analysis and text processing.

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Finally, I should like to thank my parents Manuel and Celeste, my brother Custódio, and my Portuguese friends, especially Adelaide, who wrote to me encouraging letters. Without their support the word "saudade" would have a much stronger bitter taste.

General Abstract

This dissertation examines serial position effects in several memory tasks with especial emphasis on the recency effect. Traditional views that regarded recency as the result of trace strength, retroactive interference, the output of a short-term store and a retrieval process were discussed both for short- and long-term memory tasks. A discussion of the literature in the first four chapters indicates that these views can not entirely account for all data available, and thereby a new perspective is put forward in chapter five.

In order to account for serial position effects, particularly obtained with infrahumans, preverbal infants and in incidental memory tasks, this dissertation suggests a common mechanism responsible for primacy and recency. It is claimed that primacy and recency effects may be an automatic process based upon the distinctiveness or the temporal discontinuity of the ends-of-a-series of items and the need to keep track of past events. In addition, these processes will strengthen other mechanisms shown in the literature as responsible for primacy and recency.

The experimental work was reported in chapters six, seven and eight. Experiment one was carried out to reveal the locus of age deficits in the serial position curve. The results indicated that ageing deficits were particularly located at primacy and recency, when a more demanding memory task was used.

Chapter seven is an attempt to investigate the claim that the recency effect is a low level retrieval strategy used in the absence of a semantic cue. Three experiments were run to test this claim. The results indicated that recency was still evident on a list recency task, even when highly categorized verbal materials were selected.

Chapter eight explored the presence of recency effects in a naturalistic setting and examined the effects of elapsed time and interpolated events in three experiments. Among other findings, the results exhibited clear long-term recency effects on memory for car parking and demonstrated that the forgetting observed was not due to elapsed time.

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Chapter 1: SERIAL POSITION EFFECTS AND RECENCY IN STM TASKS

1.1. Serial Position Effects
- 1.1.1. History and review
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SUMMARY

This chapter starts with an overview of serial position effects and the variables affecting each segment of the serial position curve. The recency effect is then examined in detail in the standard free recall task. The main findings are reported as well as the interpretations that have been put forward to account for the effect. Research obtained with the Brown-Peterson task will be taken into account to clarify some issues and occasional references will be made to the primacy effect whenever it is considered appropriate.

1.1. Serial Position Effects

1.1.1. History and review

One of he most thoroughly investigated phenomena in recent memory research has been the serial position curve for single-trial free recall. In single trial free recall, subjects are given a supra-span list of items (e.g., words, nonsense syllables, etc.) one at a time and are asked to recall them in any order. After the first list has been recalled, a second list of new items is presented and recalled, and so on for several other lists. The outcome is called the serial position effect and summarizes the recall for each item as a function of its position in its own list, expressed by a slightly bow-shaped and asymmetric curve.

The serial position effect is so large and easy to replicate that it has attracted extensive attention since Ebbinghaus' time. In general the effect consists of three components: first, the items that occupied the positions at the end of the list are usually recalled best; this is called the recency effect, because the items are the most recent. The items at the beginning of the list tend to be recalled less reliably than those at the end, but recall of these items is superior to those in the middle. This is termed a primacy effect, because the items were presented first in each list. Finally, if one excludes the primacy and recency portions of the list, the probability of recalling any of the remaining

words is about equal for all of them, producing the flat portion of the curve. Also, the recall of items in the middle of the list exceeds what would be expected by chance. This pattern is quite stable and has been obtained by many investigators (e.g., Murdock, 1962).

Ebbinghaus (1885/1964) gave us the earliest report of the serial position effect. He observed that in lists of syllables, numbering more than seven, the first and last syllables were learned much faster than the items in the middle of the list. Usually the first few items were learned faster than the last. However, when free recall (*) was used, the last few items were recalled much better than either the initial or middle parts of the list.

Since the early 1960s many investigators have tried to study which variables influence each portion of the serial position curve. In addition, they were curious to know if each position or segment of the curve was affected or not by the same variables. As we will see next, serial position effects attracted a lot of interest and research, because it was believed for a long time, that the serial position curve was an important tool for psychologists to study memory (e.g., Lindsay and Norman, 1977, p. 341).

(*) In a free recall task, subjects output the items of a list in any order they wish. Unlike serial recall, where output order matches the input presentation of the items, subjects in free recall tests are unconstrained by the order of the items in the list. During this dissertation the word "recall" will be presented very often, and, unless otherwise said, it should be interpreted as free recall.

1.1.2. Determinant factors

In a review of the main research that has focused on each three segments of the serial position function, the major factor that has been shown to influence primacy is rehearsal. If subjects are instructed to rehearse an item only when it is being presented (e.g., Glanzer and Meinzer, 1967; Gorfein, 1970; Fischler, Rundus, and Atkinson, 1970; Bjork and Whitten, 1974; Brodie and Prytulack, 1975; Glenberg et al., 1983), or if the memory task is disguised in an incidental learning task, where the rehearsal strategy is minimized (e.g., Marshall and Werder, 1972; Baddeley and Hitch, 1977; Glenberg et al., 1983), then the primacy segment is very much reduced or eliminated.

Among the factors that have been found to influence negatively the asymptote or the middle segment of the serial position curve are: (1) Presentation rate, such that faster rates decrease the asymptote level (e.g., Murdock, 1962; Glanzer and Cunitz, 1966; Glanzer and Razel, 1974; Leicht, 1968; Raymond, 1969; Craik and Levy, 1970; Gianutsos, 1972; Bernbach, 1975; Brodie and Prytulak, 1975; Brodie and Murdock, 1977). (2) List length, such that the longer the list the lower the recall level (e.g., Murdock, 1962; Postman and Phillips, 1965; Lewis-Smith, 1975). (3) Concurrent task, such that the greater the activity subjects are involved at the same time the to-be-remembered items are presented, the lower is the recall level (e.g., Baddeley and Hitch, 1974; Murdock, 1965; Glanzer and Meinzer, 1967; Gorfein, 1970; Silvestrein

and Glanzer, 1971; Richardson and Baddeley, 1975);

In contrast the asymptote is enhanced by certain features of the to-be-remembered items, (4) Item pronounceability (e.g., Meunier, Stanners, and Meunier, 1971); (5) Item meaningfulness (e.g., Deese and Kaufman, 1957; Raymond, 1969; Glanzer and Razel, 1974); (6) Semantic relatedness (e.g., Craik and Levy, 1970; Bruce and Crowley, 1970; Glanzer, Koppennaal, and Nelson, 1972; Glanzer, 1976); (7) Acoustic similarity (*) (e.g., Craik and Levy, 1970; Bruce and Crowley, 1970; Glanzer, Koppenaal, and Nelson, 1972; Watkins, Watkins, and Crowder, 1974); (8) Word frequency, (e.g., Sumby, 1963; Raymond, 1969); In addition, recall is enhanced by learning strategies, such as (9) depth of encoding, such that deeper encoding increases recall level (e.g., Seamon and Murray, 1976; Glanzer and Koppenaal, 1977). Finally age differences have also been observed, such that the asymptote is higher with younger than elderly subjects (e.g., Arenberg, 1976; Salthouse, 1980; Parkinson, Lindholm, and Inman, 1982; Wright, 1982; and experiment one of this dissertation).

Factors identified as influencing the recency portion of the serial position curve include: (1) postlist activity; when 10-30 seconds of interpolated activity is required, the recency segment is greatly reduced, if not completely

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(*) Acoustic similarity has a beneficial effect on free recall, whereas in serial recall the effect is inhibitory. It seems that with high acoustic similarity there are fewer reliable order cues in serial recall than with low similarity (e.g., Watkins, Watkins, and Crowder, 1974).

eliminated (e.g. Postman and Phillips, 1965; Glanzer and Cunitz, 1966; Baddeley and Hitch, 1974, 1977; Bjork and Whitten, 1974; Brodie and Prytulak, 1975); (2) Output order, with the size of recency being greatly reduced when the last few input items are recalled last (e.g., Tulving and Arbuckle, 1963; Murdock, 1963; Watkins and Watkins, 1974; Goodwin, 1976; Brodie and Prytulack, 1975; Dalezman, 1976); (3) Sensory modality, such that greater recency is obtained with auditory rather than visual presentation (e.g., Murdock and Walker, 1969; Watkins, 1972; Richardson and Baddeley, 1975; Gardiner and Gregg, 1979; Gardiner, 1983; Glenberg, 1984).

1.1.3. Individual differences with human and infrahuman subjects

Memory performance in humans, related to individual differences due to formal schooling, intelligence, development and ageing have revealed differential effects on the serial position function. In general, formal schooling has a positive effect on primacy but not on recency. Wagner (1978) tested children and young adults, ranging in age from six to 22 years and contrasted orthogonally the effects of schooled and nonschooled variables with an urban and rural environment in Morocco. Results from a serial short-term recall task indicated that recency was invariant with age, schooling and environment, whereas primacy increased with age, only when coupled with schooling and, to a lesser extent, urban environment.

These findings were supported by previous research comparing free recall of prerecency items with age. In Thurm and Glanzer's (1971) study, six year old children showed significantly higher recall performance for the prerecency items than five years old children. Cole, Frankel, and Sharp (1971) studied free recall of children in the first, third and eight grades. The results indicated that age differences were only restricted to early and middle portions of the list. These results were explained according to the view that primacy is due to rehearsal activity during the list presentation. Thus the older the subjects, the more they rehearse and the better recall performance will be.

However, Huttenlocher and Burke (1976) challenged the view that differences in rehearsal capacity are responsible for development changes in memory as revealed in serial position function. These investigators compared performance of first, third, and fifth grade children on serial recall of several lists with lengths from four to eight digits. The results showed that primacy was just as pronounced in first graders as in the the third and fifth graders. They stressed the view that the development of span with age may be more related to item identification and order encoding than with active strategies.

As far as intelligence is concerned, Fagan (1972) compared superior IQ children (mean = 128) with average IQ children (mean = 96) in a free recall task. The mean age of both groups was 10.7 years old. Children were instructed to rehearse the words aloud during each 10-word list

presentation. The high IQ group produced both a greater amount of rehearsal and a higher level of recall for the prerecency items, as compared with average subjects. This relationship did not hold for recency items where equivalent recall performance was obtained between the two IQ groups. These results were explained according to the view that low IQ subjects used less effective strategies, such as encoding and rehearsal, than high IQ subjects. Since active strategies seem to affect prerecency items, it was predicted that individual differences related to intelligence should be mainly observed at primacy and middle portions of the serial position function.

In contrast to these studies, Cohen and Sanberg (1977) obtained correlations between IQ and short-term memory (STM). The STM values were obtained from the recency portion of the serial position function. Subjects' age ranged from 10 to 14 years and the IQ from retarded to superior. Supra-span digit lists were presented and subjects were tested for serial recall. The results showed the predictive power of IQ to range from a maximum in the case of recall for recency items to practically zero in the case of primacy items.

In summary, evidence as to whether primacy increases with age or is dependent on IQ level is inconclusive, since only the findings from a free recall task exhibited such relationship. In addition, all previous studies considered recency and memory span as equivalent measures obtained from the serial position function. However, Baddeley and Hitch (1974) demonstrated a dissociation between recency and memory

span in adults. From a developmental perspective similar evidence was obtained by Byrne and Arnold (1981) with poor beginning readers matched for IQ with good readers. The poor readers showed significant lower digit span than good readers, but no difference in the size of the recency effect on free recall of 10-word lists. The finding that individual differences in memory span do not correlate with the size of the recency effect supports the argument that the two aspects of performance are manifestations of different memory processes (e.g. Hitch and Halliday, 1983).

Individual differences observed in the serial position function were also studied in elderly people. Since an experiment was carried out on this topic, further information will be given on chapter six of this dissertation.

Serial position effects have also been observed with preverbal infants and infrahuman subjects. Cornell and Bergstrom (1983) tested seven months old infants in a series of photographs of adult female faces in a probe-recognition test. These investigators assessed recognition memory by using a probe technique in which a photograph that had occurred in the first, second or third position in the sequence was subsequently paired with a completely new photograph. This pairing takes advantage of the infants' tendency to selectively fixate novel visual events; it is analogous to a two-choice recognition test in which recognition is incidentally indicated by relatively less attention to the previously studied stimulus. The results

indicated both a primacy and a recency effect, but there was no evidence of recognition of the face that appeared in the middle of the series. There was also no evidence of recognition of the most recenctly studied face following a 5-minute retention interval.

In infrahuman subjects, Thompson and Herman (1977) presented tone lists of one to six items to a bottle-nosed dolphin. After hearing the tone list, the dolphin had to classify a subsequent tone as either old (in the list) or new. The probability of recognizing the old sound was highest for the most recent sound presented and decreased sigmoidally for successively earlier sounds. The dolphin's performance, then, indicated a significant recency effect without any corresponding primacy effect.

In addition, Sands and Wright (1980) reported both a primacy and a recency effect on a serial probe recognition task with a rhesus monkey and a human. Both the monkey and the human were shown series of 10 or 20 coloured pictures drawn from a set of 211 pictures. After seeing the picture lists, the subjects were shown a single picture and were required to make a "same" (in previous set) or "different" judgment. The human's and the monkey's serial position curves were similar in shape; however, the human's recognition performance exceeded the monkey's recognition performance. The monkey's primacy effect was significant only at the first serial position on both list lengths. Also, the monkey's recency effect was significant only at the last serial position on the 10-item lists. On the other hand, the

monkey's recency effect was significant at the last four serial positions on the 20-item lists.

In a free recall task, Buchanan, Gill, and Braggio (1981) tested a chimpanzee, familiar with the language yerkish, on lists consisting of from one to eight words randomly drawn from one of three taxonomic categories. Serial position effects were observed for the four to eight-item lists, with statistically significant first-item primacy effects on the seven and eight-word lists, and last position recency effects on the six, seven and eight-word lists. A recency effect also seemed to be present at the next-to-last position on the five through eight-item lists. Averaged across the four to eight-item lists, the chimpanzee Lana recalled 85% of the first serial position item, 67% of the second serial position items, 95% of the last serial position items, 76% of the next to last serial position items and 61% of the remaining intermediate serial position items.

1.2. Recency in Short-Term Memory Tasks

Broadly speaking recency is the superior level of recall of the last few items in a supra-span list of discrete items. The recency effect is well established and has been observed in the literature since Ebbinghaus (1885/1964). As far as the features of the items are concerned the effect is very robust. Recency effects have been observed with almost all types of materials, from nonsense syllables and words to episodes in one's life. However, the recency effect is mainly restricted to two memory tests, serial recall and free recall tests in laboratory studies. When other memory tests such as recognition and cued recall are used, it is unusual that the last few items show a substantial improvement relative to the previous items in the list. In contrast, recency has been obtained in a recognition test in some naturalistic studies.

Under laboratory conditions, investigators have attempted to study the nature of the recency effect in several different tasks, whose description, analysis and interpretation would be the aim of first three chapters. The fourth chapter will be devoted to other observations of the effect under less constrained settings, mainly in naturalistic memory studies.

1.2.1. The standard free recall paradigm

Recency effects were first observed and studied in the

standard free recall task, where subjects are presented with several supra-span sequence of items. If the free recall test follows immediately the presentation of the terminal item, a large recency effect is usually observed. This task was adopted very often among researchers since the variables affecting its results were considered to be relevant to the study of memory structures and processes.

1.2.2. Interpretations of recency

1.2.2.1. Trace strength hypothesis

One of the earliest explanations of the recency effect was based upon the trace strength hypothesis. This conceptualization assumes that there is a more or less one-to-one correspondence between the physical stimulus and the memory representation or memory trace.

The theory holds that the traces and the associations or representations between traces in memory fade or decay over time. The closer the memory traces are to the present, the more strongly they are represented in memory. Depending on a number of factors, such as rehearsal, familiarity, etc., the trace may be maintained and become a part of the long-term store, or it may disappear for lack of rehearsal. If traces or associations between traces are repeated or rehearsed during the learning process, the bond between the pair members grows stronger. Once rehearsal stops, the bond or memory trace begins to decay. Trace decay is assumed to be a passive

process.

In its earlier version, time was the central variable for the trace strength hypothesis. More recently it has been claimed that it is not time that causes decay of the memory trace, in the same way as time is not responsible for the rust in cars or the ageing in human beings. According to this account decay of information in memory is an operating characteristic of the system. The structure of the system and its internal state changes over time, but it is independent of external events and therefore of interference. The memory trace strength can be conceptualized as a decreasing function of the time in store, as expressed by the lag between the item's presentation and the recall test.

According to the trace strength hypothesis forgetting of the memory trace is less for the items closer to the present; the more recent they are, the more strongly they are represented in memory. Therefore, the recency effect is attributable to the shorter time between learning and recall of the last items (e.g., Robinson and Brown, 1926; Tulving, 1968). In addition, the trace strength hypothesis can account satisfactorily for the reduction of the recency effect when a filled retention interval is used at the end of a list, as well as with changes in the output order. In both cases, the traces of the last few items are assumed to have decreased to the average strength of the middle list items.

The memory research supporting the concept of trace strength or trace decay as a function of elapsed time is weak, yet it is interesting to report the process of exploring the

decay hypothesis. Ebbinghaus (1885/1964) reported that as time passed following the learning of a list, more and more forgetting occurred. This observation and others of this kind led theorists working at the turn of the century to believe that the passage of time determines forgetting. Thorndike (1913) conceptualized the decay of memory traces with the passage of time in his "law of disuse", as opposed to the "law of practice". The "law of disuse" simply states that if the bond between stimulus and response is not practiced it will gradually decrease in strength and finally be lost completely.

The notion of memory trace decay was for some time mainly advocated by British psychologists for short-term memory (e.g., Brown, 1958; Conrad and Hille, 1958; Broadbent, 1958; and the americans Peterson and Peterson, 1959). Despite its intuitive appeal, the decay theory is very difficult to test over long periods of time in the absence of all sources of interference.

Conrad and Hille (1958) systematically varied the rate of presentation of a list of digits, which subjects were asked to recall. According to decay theory, recall should be better for the fast presentations, since less time would have elapsed between presentation and recall. The results showed that the faster presentation rate produced about 10% better recall, thus supporting the trace decay hypothesis.

In an attempt to further clarify the question of decay versus interference, Waugh and Norman (1965) used a probe procedure task. In this task, subjects were presented lists of 16 digits. The last digit in every list was as a probe

digit, one that had appeared earlier in the list at a predetermined location. The subject was required to respond by giving the item that had followed the probe digit on its earlier presentation. The rate of presentation was one or four digits per second. The results showed that the rate of presentation had no significant effect on the level of recall.

More recently, Reitman (1974) used a different technique to produce data consistent with a decay concept. The subjects in her study were asked to retain five words during a retention interval of zero or 15 seconds. During the retention interval her subjects were required to listen for a soft tone embedded in white noise or to detect the syllable "toth" embedded in a series of "doths". Subjects pressed a button whenever they heard the signal (tone or syllable) in the two conditions. The number of tones or syllables was varied from one to 14 and the signal-to-noise ratio was adjusted for each subject so as to achieve a detection probability of 50 percent. This was a difficult task, but was it enough to prevent subjects from rehearsing?

The rationale of Reitman's procedure was to occupy subjects attention with a nonverbal detection task. Unlike the Brown-Peterson task (*), this detection task was assumed to be difficult enough to prevent subjects from rehearsal,

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(*) In the Brown-Peterson task subjects are given a trigram to hold in memory over a retention interval that varies across trials from zero to about 18 seconds. A trigram is a nonsense syllable made up of three consonnants. To prevent rehearsal of the trigram during the retention interval subjects are usually required to count backwards by threes, starting with a three-digit number that is given immediately after the syllable is presented. (Cont. next page)

while producing no new inputs into short-term memory other than the to-be-remembered five words. In this sense the major shortcoming of the Brown-peterson task was that the counting by threes produced new inputs into short-term memory and it was therefore a possible source of retroactive interference.

In Reitman's experiment, the results of the experimental and control groups seemed to indicate that most subjects did not rehearse when asked not to do so. By using further procedures and analysis to discover the subjects who rehearsed during the retention interval, Reitman was able to select a small sample of 10 subjects out of 53 who probably did not rehearse. The data from these critical subjects showed between 12 and 35% forgetting within 15 seconds for the tonal task, which was attributed to time-dependent decay, in the absence of interference effects. In addition, all groups forgot significantly more (47 to 56%) when the interpolated task consisted of syllables rather than tones.

The occurrence of more forgetting at the longer delay suggests that the forgetting resulted from time decay. But a decay interpretation can not be accepted fully unless alternative interpretations have been ruled out. A serious

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(...) Each subject receives many trials, with each trial involving the retention of a different nonsense syllable. On some trials the retention interval is set to zero seconds (i.e., subjects recall the syllable immediately after its presentation) on some trials after three seconds (filled with counting backwards, for example), and still other trials at longer intervals, up through 18 seconds. Recall performance is measured in terms of the proportion of subjects recalling trigrams at each of the retention intervals. The results obtained by Peterson and Peterson (1959) with university students showed a negative accelerated curve as a function of the retention interval.

objection could be that proactive interference might have built up over trials. When the Brown-Peterson task is used in an experiment it occurs very often that recall performance is almost perfect at all delays on the first trial. There is a study, however, where the effects of decay in the absence of proactive interference were examined. Baddeley (1976) tested 922 subjects on only one trial in order to prevent the build up of proactive interference. Their results revealed that forgetting increased as a function of the length of the retention interval up to five seconds than levelled out.

Roediger, Knight, and Kantowitz (1977), however, have pointed out an additional problem with Reitman's modest demonstration of short-term memory decay. They argued that it has not yet been demonstrated the maintenance rehearsal of the to-be-remembered item and the tone detection distracting task drew on the same attentional resources. It might be that these different tasks tap different attentional resources and therefore subjects are able to attend simultaneously to both tasks, when performed together. If this were the case, then we should not be surprised to find out that little forgetting was observed in Reitman's experiment. The subjects may have been able to detect the tones at the same time as they covertly rehearsed the verbal items.

Stating this paradox more precisely it can be argued that the more similar the distractor activity is to the verbal memory task, the greater is the likelihood of producing retroactive interference. Yet the more dissimilar the tasks are, the greater is the likelihood that subjects can do two

things at once. For example, when one is driving a car to the city centre, people often found themselves thinking about the place where to park the car. This covert verbal activity goes on, while we are detecting oncoming cars, traffic lights, pedestrian crossing paths, listening to the radio and so on, without any substantial driving disruption.

According to Roediger et al. (1977) the crucial test would be to use a distracting task with several levels of difficulty. If recall performance declined as a function of the difficulty of the distractor task, then it could be assumed that both tasks share common attentional resources. If, on the other hand, recall performance was independent of the distractor task difficulty, then it could be argued that a central mechanism allocates resources to both tasks and subjects may be able to perform the nonverbal distracting task at the same time as they retain and possibly rehearse the verbal items.

Roediger et al. (1977) replicated Reitman's experiment, but replaced the tone detection task with an easy or a difficult perceptual-motor task. A tapping task associated with a flashing light was used and the difficulty of the distractor task was varied by changing the diameters of the discs and their distance apart.

The results showed no effect of task difficulty on retention. The words were retained as well when performing the difficult tapping task, as when performing the easy one. Roediger et al. (1977) concluded that their memory retention task and the distractor tapping task did not draw on the same

limited resource pool.

Returning to the Reitman's experiment we could argue that if rehearsal and tone detection did not require access to the same attentional resources, one should not be surprised that little forgetting occurred on her experiment. The subjects may have been able to detect the tones at the same time as they covertly rehearsed the verbal items.

Roediger et al. (1977) results have seriously questioned that forgetting in short-term memory tasks is due to trace decay, when either a verbal or nonverbal distractor task is used. When Brown (1958) and Peterson and Peterson (1959) introduced the distractor task, it seemed to be a simple tool for demonstrating the loss of information in short-term store due to time decay. As we have just seen the distractor task is considerably more complex and its interpretation less clear. We still do not know for sure if forgetting in short-term memory tasks is due exclusively to interference, or if time plays any role.

In the absence of a distractor task, Waugh and Norman (1965) explained their results obtained with the serial probe recall task as dependent only on the number of the interfering items and not on presentation rate. Yet they reported a slight interaction between percent recall and the rate of presentation with recall for the fast rate presentation being better for the most recent items and worse for the last ones presented. Shallice (1967; reported by Baddeley, 1976, p. 135) has interpreted this interaction as some evidence for decay, since the faster items have been in memory for a

shorter length of time. However, Baddeley (1976) accepted the view that interference in the Waugh and Norman (1965) experiment is the primary cause of forgetting in this short-term memory task.

In summary, the trace decay hypothesis with all its immediate appeal to explain the better performance of recent presented items does not seem to account for any substantial part of the recency effect obtained in the Brown-Peterson type tasks.

1.2.2.2. Interference theory

At the end of the 1950s, Postman (1961) claimed that interference theory occupied "an unchallenged position as the major significant analysis of the process of forgetting", (op. cit. p. 152). Within the associationist approach to memory studies, interference theory was one of the most widely studied and perhaps the theory that accounted for most of the data in paired-associated learning, serial recall and free recall tasks until the 1970s. Even so the assumption that the serial position curve reflected variations in the amount of proactive and retroactive interference at recall was never taken very seriously, even in the 1960s, when interference theory was a powerful explanation of forgetting and the serial position function was at its highest point in attracting the intellectual resources of many investigators. One of the reasons may have been due to the existence of alternative explanations of the serial position effects, such as the view

that the curve reflected the outputs of different memory stores, or was the result of output order. Besides, output interference was a close relative of interference theory and it seemed a better testing ground than the classical proactive and retroactive interference approach.

However, Postman and Phillips (1965), in a study on the effects of interpolated activity during the retention interval following lists of words, put forward an explanation of serial position effects that was closer to classical interference theory than previous explanations. They claimed that each item in the list was subject to retroactive interference from subsequent items and proactive interference from preceding items. As the end of the list approaches, the number of items interpolated between presentations and recall decreases. At the same time the number of prior items increases. Therefore, retroactive interference must be expected to decline and proactive interference to increase as a function of serial position.

In addition, Postman and Phillips (1965) claimed that the terminal items of a list should have a clear advantage in an immediate test of recall, since they are subject to little or no retroactive interference, and proactive interference is minimal at the beginning of the retention interval. The assumption is that retroactive interference is maximally effective immediately after an interpolated activity, but proactive interference develops only gradually after the end of learning.

According to Postman and Phillips (1965) the primacy

effect would reflect relative freedom from interference by preceding items. The earlier an item is presented in the list, the larger is the interval between presentation and test and therefore proactive interference becomes less effective with large temporal lags (e.g., Postman, 1962). In contrast, the emergence of the recency effect at the end of a list was explained on the grounds of both trace decay and output order. Due to the availability of the recency items at the beginning of the recall period they have the highest probability of recall and they are thus recalled earlier than other items. The reduction of the recency effect after an interpolated retention interval was assumed to be due to retroactive interference from the counting task.

Another version of proactive interference (PI) claims that PI is a function of both the number of preceding items and the time that elapses during the retention interval. Thus the longer the retention interval, the higher the likelihood of extinguished items will recover and then interfere with recall of items from the end of the list. This would explain the disruption of recency when an interpolated activity is appended to the end of a list and prior to recall.

The Postman and Phillips (1965) interpretation of primacy and recency effects was not widely accepted by other investigators, many of whom were much more inclined to tease out the segments of the serial position and to examine them separately.

Proactive and retroactive interference in short-term memory tasks were studied in greater detail in the

Brown-Peterson task. The degree to which these variables influence recall performance has been a matter of some controversy. Yet the studies done have helped to elucidate some issues and to guide research in new directions. Due to their relevance some of these studies will be reported next.

Retroactive interference

To prevent subjects from rehearsing the to-be-remembered items in the Brown-Peterson task, an interpolated task of counting backwards by threes is usually interpolated between the retention items and the recall test. Since the Brown-Peterson task inevitably introduces a potential retroactive interference situation, investigators have studied the retroactive interference phenomenon in short-term memory by manipulating the difficulty of the interpolated task and the similarity of the interpolated material on the retention items.

Wickelgren (1965b) varied the acoustic characteristics among consonants in a Brown-Peterson task. In his experiment, the retention items were four consonants presented at 1/2 second rate and the interpolated material eight consonants presented at the same rate. The eight consonants in the interpolated task were selected with similar or different acoustic phonemes. If for example the retention items were "BTPV", the similar task would include consonants such as "CGD", and the dissimilar task, consonants such as "LFS". Three different manipulations of the acoustic similarity on

the interpolated task were performed: (1) Four acoustically similar consonants were followed by four dissimilar consonants; (2) Two similar followed by six dissimilar; (3) Eight dissimilar consonants were included. The results showed that percent recall on condition one was 50%, condition two, 61% and condition three 68%, thus indicating a substantial decrement, when the interpolated consonants were acoustically similar.

In another study, Corman and Wickens (1968) varied the temporal point when introducing the interpolated similar material. Subjects were presented with several series of digits and consonants with 20 items in each series. The instructions required subjects to repeat each letter and digit as they heard them and as soon as the series ended to recall the first three letters in the series. The consonant trigram was presented at positions four, five and six. In one experimental condition, (1) two consonants were presented close to the to-be-remembered material at positions nine and 10; In the second experimental condition, (2) the temporal points were at position 17 and 18. The control group (3) had 14 digits presented after the consonant trigram to-be-remembered.

The results showed that the percentages of items correctly recalled for each three conditions were: Condition one, 42% ; condition two, 49% and the control group (3) 61 percent. These results indicated again a significant decrement in retention with the inclusion of similar material, but no significant relationship was found between percent

recall and the temporal position of the interpolated material within the retention interval.

In a subsequent study, Dillon and Reid (1969) varied the difficulty of interpolated tasks in different parts of a 15 second retention interval. These investigators included easy interpolated tasks (reading two digits), difficult interpolated tasks (adding two digits and classify the sum as odd or even) and a mixture of both, during a 15-sec. retention interval. In some experiments, difficult or easy tasks were presented for 1, 2, 3, 4, or 5 seconds at the beginning of the retention interval. The results revealed that forgetting increased when the difficult task occurred at the beginning of the retention interval and decreased when the easy task was followed by a difficult task. In addition, Dillon and Reid (1969) showed that most of the forgetting observed occurred during the initial three seconds of the difficult task presentation.

In summary, these results indicate that retroactive interference can occur in short-term memory tasks. However, Corman and Wickens (1968) and Dillon and Reid (1969) differed on the explanations given to account for the retroactive interference observed. Cormam and Wickens interpreted their results as being consistent with an interference theory of forgetting based on the effects of item similarity and due to the high proportion of intrusion errors from the interpolated consonants.

In contrast, Dillon and Reid (1969) interpreted their results in terms of information processing and rehearsal

prevention. Forgetting occurred because the demands placed on the central processing system exceeded the capacity required to perform the interpolated task and the rehearsal of retention items. Since the memory system is assumed to be limited in the amount of information that can be processed, then the harder the interpolated task, the more difficult the rehearsal of memory items is and thus the larger the forgetting to be observed. However interesting this interpretation may be it does not explain why more rehearsal is allowed by repeating 12 items when none is a consonant (control group) than when two are consonants (experimental groups) in Cormam and Wickens (1969) experiment.

Proactive interference

Brown (1958) and Peterson and Peterson (1958) explained the forgetting function obtained on their studies due to the spontaneous decay of information residing in short-term store. Keppel and Underwood (1962) argued that the Brown-Peterson's explanation was inconclusive, since forgetting could have been due to the build up of interference across trials. They replicated Petersons' experiment, but subjects were only tested on two retention intervals, either three or 18 seconds, and on only six trigrams. Each subject was tested three times at each of the two retention intervals. The experiment was designed to permit comparison of performance as a function of the number of previous trials the subjects had received. Two major findings were observed.

First, after the first trial, almost all of the subjects could recall all of the three consonants of the trigram, even with a retention interval of 18 seconds filled with backward counting. Second, retention of the trigrams became poorer as the number of trigrams previously tested increased, and the deterioration was larger for the 18-second condition than for the 3-second one.

Keppel and Underwood (1962) interpreted the proactive interference (PI) observed in the Brown-Peterson task with the then dominant process account of forgetting in long-term memory, the unlearning and spontaneous recovery hypothesis. According to them, at the start of the retention interval the trace of the newly acquired trigram is strong and competing associations from earlier trigrams have been weakened through unlearning. However, as the interpolated period increases, there is spontaneous recovery of the prior materials, causing increasing competition in the recall of target materials. Thus, the longer the retention interval, the greater the spontaneous recovery. Yet the greater the competition, the lower the probability of recalling the correct items.

Keppel and Underwood's claim that there was no forgetting on the first trial on a Brown-Peterson task was inaccurate, since ceiling effects may have occurred. Baddeley and Scott (1971) provided a further clarification of the occurrence of PI. Ceiling effects were prevented by testing sequences of three, five and seven to-be-remembered digits and the influence of PI was examined by comparing the performance of 18 groups of about 24 subjects each tested only once. In

addition, there was another group of 18 subjects, tested three times at six retention intervals and three length sequences, making a total of 54 tests per subject. The interpolated interval was filled with a letter copying task. The results showed that, when ceiling and floor effects were prevented and subjects were tested only once, there was indeed forgetting on the first trial and it increased from zero to five seconds levelling off afterwards. When subjects were tested repeatedly the rate of forgetting was much larger, mainly at longer intervals.

Release from proactive interference

There is evidence that similarity among to-be-remembered items is a critical factor in producing interference in long-term memory. Wickens, Born, and Allen (1963) argued that forgetting in the Brown-Peterson task should also depend upon the degree of similarity between successive to-be-remembered items. To test this hypothesis a control group was tested on four successive trials with similar stimulus material (e.g.,three consonant items on each four trials). The experimental group was presented on the first three trials with three digit trigrams and was shifted to a consonant trigram on the fourth trial. On the critical fourth trial both groups received the same stimulus material under the same conditions and both had had three prior trials in the task. However for the control group these prior trials employed the same stimulus vocabulary as the critical trial,

whereas for the experimental group the previous experience was with dissimilar items. The results between control and experimental groups on the shift trial showed that performance of the experimental group was restored nearly to the level of the first trial. Thus the build up of PI is also largely due to the characteristics of prior trials.

Wickens and his associates and several other researchers used the release from proactive interference technique to investigate which stimulus dimensions lead to release from PI, when there is a shift from one feature of the materials or conditions to another. The shifts that has been shown to produce a larger effect of release from PI were semantic features; physical, syntactic and other types produced a smaller release effect (see Wickens, 1972 for a review).

The locus of proactive interference

Wickens (1972) suggested that the effects of PI are localized at the acquisition phase of the to-be-remembered item. There are some support for this hypothesis in the Brown-Peterson paradigm: (1) The build up of PI has been found in a recognition test, which is assumed to circumvent retrieval difficulties (e.g., Gorfein and Jacobson, 1973); (2) Some studies have found a build up of PI effect in a final test of all items. Carey (1973) for example tested two groups of subjects in a Brown-Peterson task: one recalled the items in the usual way; the other was never tested on the list

items. Both conditions revealed a decline in performance across trials in final recognition, thus suggesting that later items were less well encoded and registered than earlier ones.

Watkins and Watkins (1975) argued that the locus of PI could be at retrieval rather than at acquisition phase. According to them the inference that recognition circumvents complex retrieval processes is based on the assumption that there are not retrieval difficulties in a recognition situation. Yet there are studies where subjects fail to recognize items that they can recall (Watkins and Tulving, 1975), and this failure to recognize items known to be in memory provides strong evidence for retrieval difficulties in recognition as well.

Watkins and Watkins (1975) tested the acquisition interpretation against their own interpretation of build up of proactive inhibition as a cue overload effect. A long series of Brown-Peterson trials were presented (18 trials plus two buffer trials to prevent primacy and recency effects) with the items in each block of three trials belonging to the same conceptual category and with initial recall tested only occasionally. The final recall of items from initially untested categories was equivalent across trials and thus independent of the list position within each category. It may therefore be concluded that the reason why the second trial of a Brown-Peterson trial sequence shows lower recall initially than the first is not because it is less well processed in the acquisition phase. If it were in fact less well encoded than the first item, then in final recall it would be at a

disadvantage as well as in the initial recall.

Watkins and Watkins (1975) results may suggest that the items of successive lists are equally well registered in memory, but become more difficult to retrieve. Thus the authors advocated a pure retrieval interpretation of the build up and release from proactive interference effects based upon a cue-overload principle. The principle states that the "efficiency of a functional retrieval cue affecting recall of an item declines as the number of items it subsumes increases (op. cit. p. 443).

Some of the most compelling support for the interpretation of proactive interference as a retrieval failure came from a release from proactive interference experiment carried out by Gardiner, Craik and Birtwistle (1972). This study used words from a single taxonomic category (e.g., flowers or games) which could be divided into two distinct subcategories. Flowers divided into garden or wild flowers, and games divided into indoor or outdoor games. Subjects received four successive Brown-Peterson trials in which all items were drawn from the same general category (e.g., games). The category "games" was presented as a cue on trial one and then no cues during trials two and three. On the fourth trial subjects were divided into three groups: (1) One group was presented with the new subcategory name (e.g., indoor games) prior to the presentation of the three to-be-remembered words; (2) another group received the new subcategory name at the end of the interpolated task and prior to recall; (3) the third and control group was never informed

of the subcategory shift.

Gardiner et al. found that the two informed groups about the shift from one subcategory to another showed substantial and equivalent release from PI, while the control group showed no release. This result has been very often quoted as given support to the interpretation that PI is a retrieval mechanism, since cueing after the retention interval in the second group could not have affected initial storage.

The major problem with such explanation is that it works on the other way round. Because there was neither performance differences between the two cued groups nor design differences between control and cued group one at presentation, the release effect could have been due to storage changes. The input cue could have helped differentiate the target item from the other items in short-term memory, so there may have been a facilitated transfer process. Furthermore, since a retrieval cue was not available after the interpolated activity for the group with cue at presentation, then the release from proactive interference (RPI) for that group might have as well be due to storage changes. If an additional group had been run which had the cues both at input and output, then it is likely that the relative role of storage and retrieval still could not be assessed. For example, if the additional group (cue at both input and output) showed the most RPI, a result that seems likely, then it is impossible to interpret the mechanism for the additional RPI. It could be due to an additional retrieval facilitation on top of a storage facilitation or it

could be due to greater retrieval facilitation, because of the match between the output cue and the input cue, as would be predicted by the encoding specificity hypothesis (Tulving and Thompson, 1973).

Overall, it seems that proactive interference and RPI are neither a matter of storage alone nor retrieval alone. Like many other memory phenomena they are a joint manifestation of what has been encoded and how what has been encoded is being retrieved.

For almost two decades the Brown-Peterson task was in the forefront of the research in short-term memory. Some investigators claimed that research in this area was one of those topics where psychologists could point out with some satisfaction. Others would claim that despite the research done we still do not have a clear idea about the mechanisms involved in the Brown-Peterson task. For example does the forgetting function involve a single component or two separate components, as Baddeley and Scott (1971) have suggested? What is the precise effect of the interpolated task on the verbal memory task? Does the interpolated task and the verbal memory task draw on the same attentional resources or not? And finally, is the cause of forgetting located at storage, retrieval or both?

As in other sciences, scientists sometimes abandon a task or technique, not because it was found irrelevant, but because it failed to produce and answer the appropriate questions in which they are interested. The decline in output

research in the Brown-Peterson task in the past 10 years seems to me an appropriate example within the memory research.

We will return later to the interference theory when discussing the long-term recency effects.

1.2.2.3. Output order

Recency effects in the serial position curve have been explained as the result of interference due to output order. It was observed that when subjects recall a list of items in an experiment, the order of recall determines to large extent the type of serial position function to be obtained.

Several experiments have shown that if recall of the last item is delayed by asking subjects to recall the early items of the list first, the visual shape of the recency effect is severely affected (e.g., Raffel, 1936; Murdock, 1963; Tulving and Arbuckle, 1963). In contrast, the early and middle items of the list are in general independent of recall order.

The experiment reported by Tulving and Arbuckle (1963) illustrates clearly the effect of output order. In this experiment, subjects learned a 10-item paired associate list, with the numbers zero to nine as stimuli and nonsense syllables as responses. The order of presentation and test was arranged so that each item with a given input was recalled in every output position. The results have shown that recall of items in the last few serial position inputs (e.g., 9 and 10) were very well recalled, if subjects were asked to recall

them early in the output position (e.g., 1 and 2). In contrast, when the same terminal input items were attempted to recall later in the output order (e.g., 9 and 10) the recall performance was strongly diminished.

The results further revealed that output interference does not seem to operate on recall of early and middle input items. Thus the availability of earlier items in the list does not change during the output sequence, whereas that of late items does change if it is delayed by recall attempts of other items. Therefore output interference affects the recency effect, but not the primacy and middle list items.

Although Tulving and Arbuckle (1963) used a paired-associate task, several other studies have been carried out to investigate the effects of output order in the standard free recall task. It has been observed in single trial free recall tasks that the magnitude of the recency effect increases with practice, whereas the primacy effect declines (e.g., Dallett, 1963; Katz, 1968; Keppel and Mallory, 1969; Maskarinec and Brown, 1974).

When Maskarinec and Brown (1974) presented subjects 10 word lists for immediate free recall the results revealed an increase in positive recency in immediate free recall across lists. Goodwin (1976) replicated this finding when investigating performance changes in the serial position function during the course of single free recall tests. The results have shown a reduction from list one to list five in the magnitude of the primacy effect with a concomitant increase in recency. In general, primacy items tended to be

recalled first on list one, while recency items were recalled first on list five. Thus primacy and recency portions of the serial position curve were both altered as a function of practice, but changes at one end of the curve occurred more or less independently of changes at the other end.

Goodwin (1976) argued that primacy and recency were not the result of identical mechanisms. It would appear that recency increases with practice as a function of changes in retrieval strategy, whereas primacy decreases mainly as a result of the build up of interlist proactive interference.

Performance changes in primacy and recency were also obtained, when Dalezman (1976) varied output order by recall instructions during immediate, delayed and final recall. Immediately prior to recall, subjects were visually cued with one of four instructions, (1) free recall; (2) recall firstly the initial five items and then free recall the remaining 10 items; (3) first recall the middle five items and then the others; (4) first recall the terminal five items and then the others. The results revealed that serial position effects varied with changes in the output order. Thus, items receiving early output priority had higher recall probabilities than later recalled items. The original finding of this study was that positive recency effects were obtained even during delayed recall and final recall when terminal input items were given early recall priority.

It is worth pointing out in the studies just described that the changes in performance were not due to changes in the overall recall. In fact in all these studies overall recall

remained fairly constant regardless of the number of lists or the output order selected.

Why do practice and output order affect recency? Maskarinec and Brown (1974) argued that subjects, over the course of learning several constant length lists, come to anticipate the end of the list and adopt the strategy of simply maintaining terminal list items in a buffer store until they can be recalled immediately after list presentation. There is no reason for the subjects to engage in complex processing of end items to assure their recall.

Watkins and Watkins (1974) tested the claim that changes in the recency size due to practice effects were the result of an increased knowledge of list length. In their study, the knowledge about the end of the list, or the lack of it, was manipulated with lists of various length. The results showed a negative recency effect on a final recall only when subjects were aware of the number of items in a list. They argued that subjects developed a strategy of simply maintaining the items for output on immediate recall. When the subject knows that the list is about to end, and this knowledge presumably increases with practice, it becomes apparent clear that keeping these last few items in a "buffer store" and then quickly dumping them at the beginning of recall is a highly functional strategy.

The effects of output order on recency observed by Dalezman (1976) were interpreted as the result of retrieval cues associated with the beginning and end of a list. This explanation was adopted from Tulving (1968) and Shiffrin

(1970). Due to its relevance a specific section of this chapter will be later devoted to the retrieval hypothesis.

1.2.2.4. Output from short-term memory

We have just referred to investigators who have argued that subjects become progressively aware of the end of a list of items presented for recall and keep the terminal items in a "buffer store" in order to dump them at the onset of recall. When Postman and Phillips (1965) and Glanzer and Cunitz (1966) demonstrated that a filled retention interval presented at the end of each list reduced or eliminated the recency effect, it seemed a logical step at that time to incorporate primacy and recency effects as reflecting the output of two memory stores. In addition, the findings of several studies reported earlier in this chapter have shown that certain experimental variables affect some segments of the serial position function while leaving other segments unaffected. Such findings provided most of the empirical evidence for the conceptualization of memory as a system based upon two different stores.

In the two-store model recency was attributed to a labile and highly accessible short-term store, while prerecency items were considered to be recalled from a more permanent and larger capacity store, the long-term store.

The distinction between long-term and short-term storage was firstly suggested by Hebb (1949) and Broadbent (1958). However, the experimental work on the short-term memory started with Conrad (1957), Brown (1958), Peterson and

Peterson (1959) and culminated with two of the most detailed and influential multistore models in the 1960s formulated by Waugh and Norman (1965) and Atkinson and Shiffrin (1968).

In brief, the principal feature of these memory models is the assumption that information gathered by our sensory system is rapidly transferred to a short-term store and is either replaced by other incoming information or held there by rehearsal. With other information coming in, as in the serial position function, information held in the short-term store is displaced by new information. Thus in a free recall procedure, the items that occurred immediately prior to the free recall, presumably held in the short-term memory, are easily recalled because they have not been displaced yet. In contrast, the items that occurred earlier in the list are held longer and perhaps stored in the long-term memory, because they receive more rehearsal, which enhances their availability as well as their transfer to a more permanent store, the long-term store.

Convincing support for the two memory stores was given by Craik's (1970) finding of a negative recency effect in long-term memory. Craik (1970) presented ten 15-word lists for immediate free recall. Each list was immediately free recalled after presentation and typical recency effects (positive) were observed. After recall of the 10th list, subjects were unexpectedly asked to recall as many words as possible from all lists. It was found that in this final free-recall test, words presented in the last five input positions in each list had a lower probability of recall than

other list items. In short, the last few items of each list, which had shown high positive recency in immediate free recall displayed negative recency in final free recall.

Craik (1970) interpreted these results as supportive of the two-store model. Immediately after presentation of each list, the last items presented have been in the short-term memory for the shortest period of time. Thus when they are read out at the onset of the immediate free recall their processing is stopped and only a weak registration in long-term store is kept. Accordingly one would expect a positive recency effect in immediate free recall, when retrieval is from short-term store and a negative recency effect in final free recall when retrieval is from long-term store.

The Atkinson and Shiffrin (1968) two-store model of human memory included several control processes, which allow us to manipulate the flow of information within a memory store or to transfer information between stores.

Two of the most important control processes were rehearsal and encoding. Rehearsal both maintains items in the short-term store and transfers items to the long-term store. It was assumed that the more we rehearse an item, the more likely it is that we will remember that item over longer periods of time. Encoding is the second major control process and involves transforming the information in the short-term store in ways that facilitate storage in long-term memory.

Recency and phonological coding

For some time it was known that subjects' errors and confusions in short-term memory tasks were frequently phonological in nature, even when the items were visually presented (e.g., Conrad, 1964; Wickelgreen, 1965a). In a further study Baddeley (1966 a,b) showed evidence that short-term serial memory contents were poorer for sequences of acoustically similar words and long-term memory poorer for semantically similar word lists. These results were replicated by Kintsch and Buschke (1969) in a probed recall task supporting the view that the two memory stores were based upon different types of encoding.

At the end of the 1960s there was general agreement among researchers that short-term memory involved an acoustic or phonological-articulatory representation, while long-term memory representations were more semantic in nature. With this framework in mind, investigators attempted to study the links between the recency effect in free recall tasks and the articulatory-phonological format of the short-term store.

In a study of semantic and acoustic information in primary memory, Craik and Levy (1970) assigned clusters of six words, related either acoustically or semantically to the middle or the end of free recall lists. The results revealed that the recency effect was unaffected by the type of the word comprising a list, whether or not they were similar to each other in sound or meaning.

In another study on the effects of various forms of

phonemic similarity on free recall, Glanzer, Koppenaal, and Nelson (1972) studied the effects of phonemic similarity on the short-term and long-term store by interpolating three words in the retention interval following the presentation of 12-word lists. The delay words were either unrelated to the list words or resembled them phonemically or semantically. The results showed that the presence of a phonemically related word in the delay task had no effect on the number of items held in short-term store. In addition, the size of the recency effect was reduced just as much by words related to the list in sound or meaning as by unrelated ones. The Glanzer et al. (1972) and Craik and Levy (1970) studies revealed that phonemic and semantic relations had no effect on the recency effect in free recall, suggesting that it was unaffected by either type of coding.

Using a different technique, Richardson and Baddeley (1975) presented lists of words either visually or auditorily to subjects, who were required at the same time to articulate an irrelevant utterance (e.g., the word "hiya"). According to the results of previous studies, the free recall of word lists is impaired when subjects are required to engage in such articulatory suppression, Levy (1971). The articulatory suppression technique also disrupts probed recall (e.g., Murray, 1968) and memory span tasks (e.g., Peterson, 1969). Assuming that articulatory suppression interferes with phonemic coding and that the recency effect is based upon a phonemic representation, then it could be argued that the articulatory suppression technique should interact with serial

position in general and the recency effect in particular.

The results of the Richardson and Baddeley (1975) studies showed that articulatory suppression impaired retention overall, but it did not interact with serial position. In fact articulatory suppression did not affect the size of the recency effect and Richardson and Baddeley (1975) concluded that the recency effect was not dependent on articulatory coding nor on the output of a phonemic store.

Recency, rehearsal and the storage capacity

Atkinson and Shiffrin (1968) in their model of human memory assumed that information in the short-term store can be lost relatively easy in about 30 seconds through decay or displacement from new information, unless it is rehearsed. While the original information was held in short-term store, a copy of the information was transferred to long-term memory. The information in long-term memory was viewed as relatively permanent, despite the fact that it could become temporarily inaccessible or even modified by new information. As an analogy the short-term store was viewed as a "rehearsal buffer" consisting of slots that could each held a single piece or chunk of information. The maintenance and use of the buffer "is a process entirely under the control of the subjects" (op. cit. p. 31). The size of the buffer (*) was

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(*) Waugh and Norman (1965) assumed that short-term memory (primary memory in their expression) had a fixed storage capacity. (Cont. next page)

viewed as being partially under an individual's control. A larger buffer could be maintained at the expense of other activities or alternatively other activities could be engaged at the expense of a smaller buffer.

To test the assumption that the probability of transmission of information from the short-term store to long-term store increases proportionally to the amount of rehearsal, Rundus and Atkinson (1970) asked subjects to rehearse overtly, or loudly, during a study trial. Several lists of 20 common nouns were presented visually for five seconds each. By tape recording each subject's overt rehearsal activity, it became possible to count the actual number of rehearsal responses each item in the list receives. Recall performance revealed the classical serial position function. However, when the number of rehearsals as well as the probability of recall for each list item were compared, it was shown that the number of rehearsal responses decreased from the first input position in a list through the sixth input position - and so did the probability of recalling the items at those positions. The probability of rehearsal responses was similar at the asymptotic level to the recall performance at least until the recency segment emerged on the

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(...) In emphasizing the nature of the rehearsal buffer as a control process rather than as an invariant part of the memory structure, Atkinson and Shiffrin (1968) claimed that it is the processing capacity that it is limited in short-term memory rather than the capacity of the buffer. A limitation on processing capacity means that there can be various amounts of storage space available in the short-term memory depending on how busy the subject is or how well the subject is engaged in complex encoding operations (e.g., imagery or other mnemonics).

last three input positions.

Two points are worth considering in Rundus and Atkinson's study: (1) The relationship obtained between the amount of rehearsal and recall performance gave substantial support for the multistore analysis of free recall. It was assumed that increasing the number of rehearsal responses it could increase the probability of transmission to long-term store. (2) The primacy component of the recall function was highly correlated with the number of rehearsals. From that some investigators later argued that the primacy effect was largely due to the number of rehearsals given at the first input positions.

Although rehearsal may be an important determinant of the primacy effect, it is not the only one. Small primacy effects are still obtained even when subjects are required to rehearse all input items of a list the same number of times (e.g., Fischler, Rundus, and Atkinson, 1970), and, as we will report later, small primacy effects were obtained in an incidental recall task (e.g., Baddeley and Hitch, 1977).

Other empirical data available at the time supported in general the Atkinson and Shiffrin (1968) model. The size of the recency effect in free recall of unrelated word lists comprises on average five or six items (e.g., Murdock, 1962), while the memory span capacity is about seven plus or minus two chunks of information, Miller (1956). Therefore it was reasonable to suppose, as the proponents of the two-store model did, that the digit span and the recency effect represented the output of a single "buffer" store, the

short-term memory.

In a series of experiments to test this claim, Baddeley and Hitch (1974) argued that if recency and span were the output of short-term store, then a concurrent memory load equivalent to the span capacity presented at the same time subjects were listening to lists of words for immediate free recall would reduce or eliminate the recency effect.

Baddeley and Hitch (1974) presented auditorily lists of 16 unrelated words to be recalled either immediately or after a filled 30-second retention interval. At the same time subjects saw a visual display of either three or six digits presented for two or four seconds and followed by a two or four second blank interval, during which they were required to recall and write down the digits. The control group was instructed simply to copy down alternate sequences of three or six digits as they appeared.

The results plotted as a function of the serial position revealed that the recency component of the function was unaffected by either the three or six digit memory load, as compared with the control group. Baddeley and Hitch (1974) concluded that if a memory load close to the digit span capacity did not interact with the recency effect, than recency and memory span must depend on independent mechanisms. Therefore the assumption that the size and extent of the recency effect reflected the short-term memory capacity became much more difficult to defend.

Other experiments, instead of manipulating the form of rehearsal, have attempted to reduce it systematically.

Murdock (1965) asked subjects to sort a deck of playing cards into various categories during auditory presentation of a 20-word list presented at at rate of one word per second. Murdock assumed that card sorting would interfere with rehearsal, and the more difficult the sorting task was the greater the reduction on rehearsal. The results revealed that increasing the difficulty of the subsidiary card-sorting task impaired performance on the primacy and the asymptotic component of the serial position curve, but left the recency segment completely unaffected. When Shiffrin (1970) replicated this experiment, on the grounds that the subsidiary task was too easy to inhibit rehearsal, results similar to Murdock (1965) were obtained, although the recency segment was somewhat reduced relative to the control group. These results led Shiffrin (1970) to conclude that the recency effect was independent of rehearsal processes and was the result of retrieval from short-term memory.

The results of the experiments reported so far have revealed that the size of the recency in free recall is unaffected by a memory load of six digits (e.g., Baddeley and Hitch, 1974; phonological similarity of the words in the list (e.g., Craik and Levy, 1970; Watkins, Watkins, and Crowder, 1974), or as a function of articulatory suppression (e.g., Levy, 1971; Richardson and Baddeley, 1975); word length (e.g., Craik, 1968; Glanzer and Razel, 1974); presentation rate, or spacing between items (e.g., Waugh and Norman, 1965; Glanzer and Cunitz, 1966; Brodie and Prytulak, 1975; Brodie and

Murdock, 1977; Bernbach, 1975) (*).

Since the variables that largely affect digit span and other short-term memory tasks have no effect whatsoever on the recency portion of free recall of supra-span word lists, it was argued that recency could no longer be considered as the output of a short-term store. Thus alternative explanations were put forward to account for the recency effect.

Baddeley and Hitch (1974) opposed the view that the recency effect was the output of a short-term store based on the following results:

1. A concurrent memory load held by subjects, while listening to word lists, did not affect the size of the recency effect.

2. The recency effect was found with a long-term memory task, involving the solution of 12 anagram words. Subjects were required to work on each anagram for up to one minute and if the solution was not discovered on time, the experimenter would provide it after the time has elapsed. One or two minutes after solving or being told the solution of the 12th anagram, subjects were unexpectedly asked to recall as many anagrams as possible. A clear recency effect was observed. Baddeley and Hitch (1977) argued that it was difficult to explain such an effect in terms of a temporary buffer store.

Such results suggested to Baddeley and Hitch (1974) an

(*) The curious point about these variables is their influence on the size of the memory span, Brown-Peterson and probed recall tasks (see Baddeley, 1976, p. 182, for a review).

alternative explanation of the recency effect based on a retrieval process.

1.2.2.5. Recency as a retrieval process

At the time when the two-store view of the memory system was at its highest point of acceptance among researchers, Tulving (1968) preferred the view that all input information in the serial position function was stored in the same "unitary storage system" and that serial position effects "reflect primarily differences in the accessibility of the items" (op. cit. p. 13). Tulving (1968) explained the emergence of recency effects on the basis either of the permanence of the acoustic trace of the terminal items if the to-be-remembered items were presented auditorily, or when they were presented visually on the presence of an acoustically recoded visual trace. Tulving (1968) argued that this auxiliary information could serve as a retrieval cue for the terminal items.

On the other hand, the accessibility of primacy items could be due to subjects capacity to date temporarily the initial items of the list. Therefore the temporal dating of items and the supplementary acoustic information were additional cues acquired by subjects in the course of list presentation. Thus Tulving (1968) concluded that, if two types of retrieval cues were postulated, serial position effects could be explained.

Shiffrin (1970) in a major paper on memory search

argued that the recency effect should be independent of rehearsal and was the result of retrieval from short-term store. Although the emphasis on retrieval as an explanation of recency was at the time a movement against the stream, Shiffrin's main point in this study was a claim about the primacy effect, which was later generalized by other researchers to the other serial position effects (e.g., Dalezman, 1976; Whitten, 1978; Glenberg et al. 1980).

Shiffrin (1970) assumed that adjacently presented words have a higher than chance probability of being jointly recalled and are more likely than chance to be recalled successfully during output. If at some point or points during the search a draw is made, not from the search set containing all items in the list, but from the search set restricted to items near the start of the list, the search process can account for primacy effects. By assuming that the start of a list provides a natural and distinctive cue to attract the search process, Shiffrin claimed that earlier items are better recalled because such set is restricted and the search process well located.

The concept of a search-set based on distinctive positional cues, which could act as retrieval anchor mechanisms is able to account for most of the empirical data available on primacy, recency and Von-Restorff effects and it was the focus of later conceptualizations of the serial position effect, Whitten (1978).

Baddeley and Hitch (1974) reinforced the view that the recency effect reflected the operation of a retrieval strategy

based upon the higher discriminability of ordinal retrieval cues for the recent items than for any other items.

1.2.3. Overview

The view that the recency effect reflects a retrieval strategy rather than the output from short-term memory has been largely adopted among the researchers since the middle seventies. What mainly differs among explanations is the account of how ordinal cues and temporal order are encoded with the to-be-remembered items and act as anchor mechanisms within the retrieval process.

A new series of experiments, shifting from the standard free recall paradigm (e.g., Murdock, 1962) to the continuous distractor paradigm (e.g., Bjork and Whitten, 1974) as well as experiments on naturalistic and autobiographical memory have helped to clarify and make further progress on the understanding of the recency effect.

CHAPTER 2: RECENCY IN LTM TASKS

2.1. The Continuous Distractor Paradigm
  2.1.1. Prerequisites and boundary conditions

2.2. Laboratory and Naturalistic Tasks

2.3. Interpretations of Recency
  2.3.1. Trace strength hypothesis
  2.3.2. Interference theory
  2.3.3. Output order
  2.3.4. Rehearsal buffer
  2.3.5. Retrieval hypothesis
    2.3.5.1. Contextual-temporal hypothesis
    2.3.5.2. Temporal-order discrimination hypothesis

2.4. Overview

SUMMARY

Chapter two examines recency effects in long-term memory (LTM) tasks. Some of these tasks will be described, but most of the chapter will focus on the analysis of the recency effect obtained in the Bjork and Whitten (1974) task, later known as the continuous distractor paradigm. Prerequisites and boundary conditions will be reported as well as the interpretations given to account for recency effects in LTM tasks. Finally a short summary of the relevant findings as well as the points still under debate will be given.

In a paper presented at the Midwestern mathematical psychology meeting in April 1972, Whitten and Bjork described an experimental memory task that produced a large recency effect. Since the recency effect obtained was considered to be largely the result of long-term memory processes, it became known as long-term recency effect.

2.1. The Continuous Distractor Paradigm

Whitten and Bjork's task was a mixture of the Brown-Peterson and the standard free recall paradigm (*). Subjects were presented four lists of ten word-pairs to remember. Each word-pair was visually presented for 2-seconds and before or after each word-pair there was 12-second period of solving simple multiplication problems presented at the same rate as the words. Subjects were instructed to study each word-pair when being presented. At the end of each list, subjects were asked to free recall the words presented.

According to the two-store model of memory the instructions to concentrate on each word-pair along with the interpolated distractor activity should be sufficient to eliminate both the primacy and the recency effect. There was considerable empirical evidence from the standard free recall task that the primacy effect was due to the cumulative

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(*) Our attention would be concentrated on the paper published 2 years later, which was an extension and improvement of the previous study, Bjork and Whitten (1974).

rehearsal of the first few items of a list. In addition, it was well established that a filled retention interval would eliminate or disrupt the recency effect. Contrary to these predictions, the Bjork and Whitten (1974) task, or the continuous distractor paradigm (*), displayed both primacy and recency effects when the serial position function was plotted for the 10 input word-pairs.

In a second experiment, Bjork and Whitten (1974) covaried the amount of distractor activity preceding or following each word-pair (0 or 12 seconds of interpresentation interval - IPI) and the amount of additional activity at the end of each list during the retention interval (0 or 30 seconds of retention interval - RI). The design of the experiment allowed an approximate comparison between the standard free recall task (IPI-RI: 0 - 0; 0 - 30 seconds) and the continuous distractor paradigm (IPI-RI: 12 - 0; 12 - 30 seconds). At the end of the experiment, a final free recall test for all words from all eight lists was given to subjects. This second experiment was designed to answer the following questions:

1. Is the recency effect previously observed due to a long-term memory process? If so, then increasing the filled retention interval should have little effect.

2. Is the size of the recency effect equivalent in both tasks?

(*) The Bjork and Whitten (1974) task was named "continuous distractor paradigm" by Poltrock and MacLeod (1979) and this terminology would be used throughout this dissertation.

3. Will a final free recall test show recency effects when performance is plotted for either input word-pairs or input lists?

The results obtained in the second experiment with the continuous distractor paradigm again displayed clear primacy and recency effects in both conditions (12 - 0, 12 - 30), while the results of the standard free recall task only exhibited recency effects in immediate recall (0 -0). The data confirmed that a 30-second retention interval filled with distracting activity had no effect on recency in the continuous distractor paradigm. In contrast, the filled retention interval eliminated the recency effect in the standard free recall task, as was expected. This outcome produced compelling evidence that the recency effect observed in the continuous distractor paradigm were more the result of long-term than short-term memory processes.

When the performance of the terminal word-pair was compared in the three conditions producing recency effects, it was found that the recall probability was equivalent in the two conditions of the continuous distractor paradigm (about 55%), but much lower than in the standard free recall task, (about 90%) in the 0-sec. retention interval.

The final recall of all word-pairs showed different results according to the way they were plotted. If the results were plotted in terms of input serial position of word-pairs, then the recall probability displayed a flat serial position function and an absence of recency in all four conditions tested. When the results were plotted for overall

list recall a fairly large list-recency effect was observed.

In the third experiment, Bjork and Whitten (1974) tested the claim that the long-term recency effect observed previously reflected a retrieval process rather than differential storage during input. If it is assumed that recognition tests circumvent complex retrieval processes, then the absence of long-term recency effects in a recognition test would prove that the effect was largely a retrieval process. Besides immediate recall and recognition tests, a final recall test at the end of the experimental session together with a 24-hour delayed recall test were given to subjects.

The results again revealed clear primacy and recency effects, when subjects were tested for recall at the end of each list. When subjects were tested by recognition, both effects were eliminated and the same flat function was observed in the final recall at the end of the session, regardless of the fact that the word-pairs had been tested previously for recall or recognition.

On the other hand, there was a significant recency effect for lists at the end of the experimental session for both types of test used, but not after a 24-hour delayed interval.

2.1.1. Prerequisites and boundary conditions

The results of the experiments just described led Bjork and Whitten (1974) to formulate a kind of Weber-Fechner

ratio, as a sine qua non condition to obtain long-term recency effects. This ratio was a function of the values of the interpresentation interval to the values of the retention interval. According to them, the retention interval must be limited within some values in order to produce recency effects. Thus in an example given by Bjork and Whitten (1974) "if subjects were presented one list of words a day for seven days, recall at the end of the week should exhibit recency, but recall a month later should not" (op. cit. p. 188). The fact that a recency effect was observed at the end of each list, but not in a delayed total recall, when recall was plotted for input words, was explained as due to the word-pairs in the final test no longer constituted a well ordered series from the subjects standpoint. In contrast, when recall from the same data was plotted for lists, a long-term recency effect was observed for lists at the end of an experimental session, since in this case the lists constituted a well-ordered series.

Besides the ratio-rule, Bjork and Whitten (1974) claimed that a second prerequisite was crucial to obtain long-term recency effects. According to them, each to-be-remembered input, whether a single item, a word-pair or a list of items, had to be discrete in the sense that all encoding and rehearsal activities should be focused on each input item in turn, with little or no coding of relations between items.

In summary, the Bjork and Whitten (1974) experiments revealed:

1. The recency effect observed in the continuous distractor paradigm was not dependent on short-term memory processes. For this reason recency effects in the continuous distractor paradigm have come to be known as long-term recency effects.

2. An interpretation of the recency effect, in terms of the output of a labile and temporary buffer memory store, became more and more difficult to accept.

3. The recency effect is due to retrieval rather than storage processes and can be dependent on output order. In contrast to the primacy effect, recency is eliminated in a recognition test.

4. Long-term recency effects were assumed to be observed within the limited values of the ratio between the interpresentation interval and the retention interval. In addition, it was considered essential that encoding activities should be only focused on the current input item at any point in time, whether the item was a single word, two words, or a list of words.

Bjork and Whitten (1974) findings (*) on the continuous distractor paradigm have been replicated in numerous other studies (e.g. Tzeng, 1973; Poltrock and MacLeod, 1977; Whitten, 1978; Glenberg et al., 1980, 1983; Glenberg and Kraus, 1981 and experiments reported in this dissertation).

(*) The Bjork and Whitten (1974) experiments were described in some detail, because they provided both the paradigm and the interpretations that will be the object of several further studies, inclusive some experiments in this dissertation.

A series of several other experiments carried out by Glenberg and his co-workers (e.g. Glenberg et al., 1980; Glenberg and Krauss, 1981; Glenberg et al., 1983) have attempted to study other variables that might affect the size of the long-term recency effect.

Baddeley and Hitch (1974) and Bjork and Whitten (1974) reported that long-term recency effects are obtained within the values of the ratio of the interpresentation interval to the length of the retention interval. If the ratio exceeds a critical value, long-term recency effects are found. Below the critical value, recency disappears.

Glenberg et al. (1980) have manipulated several lengths of the interpresentation interval (IPI) and the retention interval (RI) in order to establish the boundaries of the ratio rule in the continuous distractor paradigm. interpresentation intervals of four, 12 and 36 sec of distractor activity were selected and factorially combined with retention intervals of 12, 36, and 72 seconds.

The results indicated that in general the long-term recency effect is dependent on the retention interval and the interpresentation interval lengths. The shorter the RIs and longer the IPIs the greater the size of the recency effect.

In a further study, Glenberg et al. (1983) have correlated the value of the ratio of the interpresentation interval to the retention interval values, from the experiment just described, with the slope values of the last three items in the list. The size of the recency effect was computed from the slope of the least-square regression line relating

proportion recalled to serial position n-2, n-1 and n, (with "n" being equal to the terminal item of the list). When the natural logarithm of the ratio of the IPI/RI was correlated with the magnitude of the recency effect, expressed in slope values, the correlation coefficient obtained was very high (i.e., r =0.93). In addition, the relationship of both variables was better fitted by a linear function, which accounted for over 80% of the variability among the mean slopes.

In two other experiments, unusually long IPIs of one day and seven days and RIs of one day and 14 days were selected. The subjects' task was to write down a short story involving two characters and two locations. Subjects were told that they were performing a creative task the experimenter was interested to observe how they will improve with practice. On the testing day subjects were unexpectedly asked to recall as many characters and locations as possible. Pronounced recency effects were obtained with one day retention interval in both IPI conditions, but the effect was absent with a 14 day retention interval, in both IPI conditions. When the same task was carried out with IPIs of five and 20 minutes and a RI of 40 minutes, the recency effect was only observed in the 20 minute IPI.

Glenberg et al. (1983) claimed to have demonstrated that the recency effect is linearly related to the logarithm of the interpresentation interval to the retention interval, whether the intervals are measured in units of seconds, minutes, or hours and weeks. Since the relationship holds

with any unit of time it is possible to predict the size of the recency effect before carrying out an experiment.

It was already known that long-term recency effects were not found in a recognition test, Bjork and Whitten (1974). Glenberg and Krauss (1981) replicated this finding with consonant-vowel-consonant syllables as materials. In this experiment long-term recency effects were obtained in a recall test, but not in a recognition test, even when the last three input positions were tested for recognition in the first three output positions.

Glenberg et al. (1983) have also studied long-term recency effects with a cued recall test. In the experiment reported, pairs of words were presented and subjects were instructed to construct a sentence to relate the two words in each pair embedded in a continuous distractor paradigm task. In the cued-recall test, subjects were given one member of each word-pair, as a cue for the other member. The results obtained indicated that the recency effect was reduced in cued recall, as compared to the size of the recency effect that would be expected from the ratio-rule in free recall.

The pattern of experiments reported so far has revealed that the size of the long-term recency effect is largely dependent on the number of explicit cues provided at test. When the cues are minimal, such as in uncued free recall, recency effects are obtained, provided that the ratio of the IPI / RI reaches a certain value. On the other hand,

when subjects are given explicit retrieval cues, such as copy cues in recognition tests, or category members in cued recall, the long-term recency effect is greatly reduced, if not absent.

2.2. Laboratory and Naturalistic Tasks

Long-term recency effects are not restricted to the continuous distractor paradigm. Baddeley and Hitch (1974) reported a long-term recency effect extending throughout the entire list in an incidental memory task, with five-letter anagrams as materials. The interpresentation interval was filled with the problem-solving and the retention interval with a short discussion about particular solution strategies subjects might have used.

Baddeley and Hitch (1977) replicated the previous study with small modifications. Again 12 anagrams were presented, but this time subjects were allowed a maximum of 30 seconds before being told the solution. In addition, during the interpresentation interval they were required to count backwards by threes for 10 or 30 seconds. The retention interval between the presentation of the final anagram and the beginning of the unexpected recall test was filled with a 30-second backward counting task.

The results obtained in the two conditions showed again clear-cut recency effects, either as a function of elapsed time or as a result of the number of intervening

anagrams.

There are two other types of tasks, where long-term recency effects were obtained. One of these is a list recency task, which will be explored in experiments two, three and four of this dissertation. Briefly, several lists of words are presented for immediate recall. At the end of the presentation and recall of the last list, there is a retention interval followed by an unexpected total recall of all words from all lists. Under this procedure, when recall performance is plotted for list serial position, a list recency effect has been obtained (e.g., Bjork and Whitten, 1974; Tulving and Psotka, 1971).

The other laboratory task is similar to the Brown-Peterson task and was used by Rundus (1980) to study the effects of word repetition. In the Rundus' task, the to-be-remembered items were 2-digit numbers, and the distractor task, a word which subjects had to overtly rehearse for a specific interval. Subjects were given 20 trials with a different word presented in each trial. After completion of all 20 trials, a 90-sec retention interval was given and then subjects were asked to recall the distractor words that had been rehearsed during the Brown-Peterson trials. Among other findings, the results showed a pronounced long-term recency effect without any correspondent primacy effect.

Recency effects in long-term memory have also been found in incidental naturalistic studies, where subjects were asked to report past events either external and shared with

other people, or personal incidents from their lives. In most of these naturalistic studies the values of the interpresentation interval, the retention interval as well as the frequency and time exposure of the to-be-remembered items were largely disregarded for research purposes. Thus due to these idiosyncrasies and the need to fit the naturalistic studies in the proper context of their appearance, a separate chapter (the fourth) was written, where more information may be obtained.

2.3. Interpretations of Recency

The explanations that have been proposed to account for the long-term recency effect are in general similar to those suggested for the recency effect in the standard free recall paradigm. A review and comments on each major explanation will be suggested next.

2.3.1. Trace strength hypothesis

The trace strength hypothesis claims that memory strength is a decreasing function of the total time between the item's presentation and the recall test. Since the last few items in a list are closer to the testing time, then trace strength is higher than for middle list or early items and thus they are better recalled.

The major evidence in favour of the trace strength

hypothesis is the fact that the long-term recency effect decreases as the retention interval increases, as can be inferred by the ratio rule (Glenberg et al. 1983). The loss of recency following a long retention interval can also be explained on the assumption that after an extensive retention interval, the traces of even the most recently presented items will have decayed to near asymptote.

The evidence against the trace strength hypothesis is not overwhelming. There are, however, two types of experiments that cast doubts on its efficacy.

Firstly, when the interpresentation interval is manipulated and the retention interval kept constant in the continuous distractor paradigm, the strength of the terminal item and its total time in store is identical. However, it has been consistently found that the longer the interpresentation interval, the better is performance on the terminal item will be (e.g., Baddeley and Hitch, 1977, fig. 9, p. 661; Glenberg et al., 1980, fig.4, p. 363; Glenberg et al., 1983, fig. 5, 6 and 7). This finding has also been obtained in free recall after an incidental or intentional learning task (e.g. Glenberg et al. 1983, fig. 6, p. 247).

Secondly, if the strength of the memory trace decays over time, then in principle it would not matter what test was used. What has in fact been observed is the absence of recency effects in recognition tests, even when the last input serial positions were tested in the first three output positions and when overall performance was below any ceiling (e.g., Glenberg and Krauss, 1981; Bjork and Whitten, 1974).

2.3.2. Interference theory

Interference theory has explained serial position effects in free recall by the separate and joint influence of proactive and retroactive interference. According to some versions the primacy effect was due to the build up of proactive interference and the recency effect to the increase in retroactive interference. Although a large amount of research has been produced to explain the cause of interference, we still do not know sufficient to rely exclusively on interference theory.

The major problem with any explanation based on interference is the lack of agreement about how forgetting is caused by interference. Several processes and mechanisms have been proposed, such as response competition and unlearning, Melton and Irwin (1940); list differentiation (Underwood, 1945); response set suppression (Postman, Stark, and Fraser, 1968); stimulus encoding variability (Martin, 1971). Although some of these processes have more experimental support than others, they may all contribute to the total interference effect observed in a particular task.

A further problem with interference theory is that even its major proponents (e.g., Postman, 1976) do not believe any longer in interference as a process which reflects the operation of identical mechanisms for proactive and retroactive interference. Postman (1976) makes the point that it "may be more valid to explore the characteristics of storage and retrieval in a given class of memory task rather

than to the formulation of principles of interference that are indigenous to that class" (op. cit. p. 179).

In the meantime, Tulving and Madigan (1970) drew a useful distinction between trace-dependent and cue-dependent forgetting. According to them forgetting was conceptualized as a failure due to either the absence of an appropriate retrieval cue (cue dependent forgetting) or the loss of the stored memory trace (trace dependent forgetting).

Following this distinction, Tulving and Psotka (1971) proposed that long-term recency effects in free recall were caused by retroactive interference. The main thrust of their paper was to argue that the retroactive interference observed was an instance of cue-dependent forgetting originating from the absence of effective retrieval cues. These researchers presented to one of several groups six different lists of 24 words, each containing six categories, each with four exemplars. Each list was shown three times before its immediate recall was tested. After the presentation of the last list, subjects were unexpectedly tested three times. In the first two tests subjects were required to free recall the words of all lists and then a cued recall test was given with the categories as cues.

When performance was tested by a free-recall procedure, the results revealed large long-term recency effects, with recall declining as a function of the number of interpolated lists. In contrast, the effects of retroactive interference on list recency were virtually eliminated when retrieval cues were provided. Under cued recall, performance

was equivalent for all lists and did not differ from the original learning tested by the immediate recall tests. Thus Tulving and Psotka (1971) concluded that retroactive interference in free recall of categorized word lists was apparently produced by the inaccessibility of higher order memory units, rather than by losses of instances of each category. Their findings were interpreted as indicating that the retroactive interference observed reflected the inaccessibility rather than the unavailability of higher order units. These results were largely replicated by Nelson and Brooks (1974) with categories defined on the basis of rhyme (e.g., boot, root, shoot, ditch, pitch, etc.)

These results and those of others (e.g., Bower and Reitman, 1972) who have shown that retroactive interference can be reduced by using a mnemonic device (e.g., the method of loci) led to the conclusion that retroactive interference can be minimized by using learning methods that provide effective retrieval cues.

It is inappropriate, nevertheless, to think that retroactive interference can be completely explained as a cue dependent rather than trace dependent forgetting effect. On the one hand, this distinction may be a simplified description of forgetting as a complex continuous dimension process, as in fact was implied in Tulving and Madigan's initial formulation of these two states (e.g. p. 473). On the other hand, Reynolds (1977), in a well-planned A-B, A-C design with a paired-associated learning task, has shown that, while cuing made some items accessible it did not provoke retrieval of all

items whose recall was inhibited by retroactive interference.

A further analysis of the errors given by subjects led Reynolds (1977) to suggest that retroactive interference was due to response-term failures as well as association failures. These results seem to suggest that retroactive interference may reflect a continuous unlearning of specific items, as Reynolds (1977) claimed, as well as the inaccessibility of higher order units of information, as Tulving and Psotka (1971) had claimed.

Although several attempts were made to interpret the long-term recency effect as a function of retroactive interference and to explain the cause of interference in categorized word lists as due to the unavailability of higher order units, the field is still open to alternative explanations.

2.3.3. Output order

The effects of interference due to output order have been shown in recency in the standard free recall task (e.g. Tulving and Arbuckle, 1963; Dalezmam, 1976; Goodwin, 1976), but not in the continuous distractor paradigm (e.g., Whitten, 1978).

Bjork and Whitten (1974) argued that long-term recency effects were dependent on a retrieval effect rather than on unequal storage. The main results supporting this conclusion are: (1) Recency effects are absent in recognition tests; (2) A final free recall of all words presented in the experimental

session plotted for input positions did not display a recency effect. If the long-term recency effect was the result of retrieval processes, would retrieval be affected by output interference or output order?

The output interference hypothesis would claim that the recall of one item would decrease the probability of recalling the next item. Assuming that subjects given a series of lists recall the terminal items in some lists, and the beginning items in other lists, this hypothesis would predict a bowed recall function, as observed. On the other hand, a recall process based on output order would claim that the ends of the list are easier and more accessible during recall and consequently are more often recalled earlier than the items in the middle of the list, regardless of interference from previous items.

In short, is recall order from both ends of a list what determines recall probability or is it recall probability that determines recall order? In order to elucidate this issue, Whitten (1978) had subjects recall six lists of nine word-pairs in one of three orders: (1) A primacy instruction required subjects to start by recalling from the first third of the list; (2) A middle list instruction was to start recall from the middle of the list and (3) A recency instruction was to start recall from the terminal word-pairs. After attempting to recall the cued section of the test, subjects were asked to try to recall the remaining words of the list in any order they wished.

If the output interference hypothesis were correct

then middle-list items, being the first items to be output, should be better recalled than primacy and recency items. On the other hand, if the instructions did not produce any recall differences, it could be argued that the output order was unrelated to output interference and probability of recall.

The results showed that retrieval instructions did not have a significant effect on recall probability. Although on average subjects followed the instructions to retrieve the middle-list items first, recall of middle items was not significantly higher than with the other instructions.

This experiment indicates that recency and other serial position effects in the continuous distractor paradigm are not largely dependent on output interference, in contrast with the results obtained in the standard free recall paradigm (e.g., Dalezman, 1976; Goodwin, 1976; Tulving and Arbuckle, 1963).

Whitten's (1978) experiment has not been replicated up to now, but a close inspection of the three output order conditions reveals a major enhancement in the recall of the terminal item in the "recency first" condition. Recall performance was 15% higher in the "recency first", than in the other two output conditions.

A second criticism may be related to subjects failure to comply with the instructions in Whitten's (1978) experiment. When the output percentile was plotted against serial position, it was clear that the average output percentile for recency and primacy items was no higher than 70% (see fig. 2, p. 688). It was evident that a few

subjects failed to obey the output order instructions.

A well designed experiment would require the replacement of subjects who failed to comply with the instructions, as Goodwin (1976) did in a standard free recall task. Since such an experiment was not carried out, it is not possible to draw firm conclusions about the effects of output order in the continuous distractor paradigm.

2.3.4. Rehearsal buffer

In addition to the ratio of interpresentation interval to the retention interval, another important factor in long-term recency effects is the instruction to rehearse only the item being currently presented. Poltrock and MacLeod (1977) argued that such a prerequisite could facilitate a strategy to keep the terminal items in a rehearsal buffer during the retention interval. According to these investigators, if subjects wish to rehearse the terminal items during the retention interval, specially when few items are held there, long-term recency could be interpreted as the output of a short-term rehearsal buffer. In fact instructions to rehearse only the current item should encourage such a strategy.

Poltrock and MacLeod (1977) claimed that the two-store model theory could account for the long-term recency effect in the continuous distractor paradigm, if it is assumed that the surreptitious rehearsal of the terminal item occurs in short-term memory during a filled retention interval.

Empirical evidence from previous studies was gathered to support such claim. According to Peterson and Peterson (1959) longer periods of distracting activity reduce recall from short-term store. Murdock (1961) and Melton (1963) showed that forgetting from the short-term store increases or decreases proportionally to the number of items in the store. Baddeley and Hitch (1974) revealed also that subjects were able to maintain a memory load of three items throughout the presentation of a list of words without affecting overall recall performance of the word list.

However, Brodie and Prytulack (1975) demonstrated that subjects disobey instructions to allocate equal-rehearsal to the items in a standard free recall task and rehearse more beginning and terminal items. These investigators called attention for the need to rely on other measures than the researcher's instructions or the subjects concurrent overt rehearsals. In fact such precautions about surreptitious rehearsal in a Brown-Peterson task had already been taken by Reitman (1974) and even so subjects were found rehearsing.

Glenberg et al. (1980) put forward four sets of evidence contradictory to the short-term store explanation, although only the last two seem convincing.

1. If it is claimed that the long-term recency effect is due to subjects' rehearsal of the terminal item stored in a temporal buffer, then the harder the filler task presented during the interpresentation interval and retention interval, the smaller should be the recency effect. Glenberg et al. (1980) manipulated the difficulty of the distractor activity

during the interpresentation interval, and during the retention interval. In the interpolated task subjects were required to solve six addition problems, each presented for two seconds. The easy interpolated task consisted of adding two single-digit numbers, while in the hard interpolated task, subjects were required to add three single digit numbers. The 30-sec. retention interval was filled with either 15 easy and 15 hard arithmetic additions.

The results showed that the size of the recency effect was largely unaffected by the difficulty of the distractor task.

It might easily be argued that adding three single-digit numbers every two seconds by undergraduate students as the harder filling task was not difficult enough to prevent total rehearsal. To prove that, a close inspection of fig. 1, p. 358 reveals that recall performance on the terminal item was marginally affected by the difficulty of the interpresentation interval task. Difficult interpresentation intervals lowered the recall performance of the terminal item by about 10 percent.

2. Even if Poltrock and MacLeod's (1977) explanation was correct, the size of the recency effect should not be raised more than one or two items from the middle list baseline. Glenberg et al. (1983) argue that the recency effect usually comprises four or five items. This is a controversial point since evidence suggests that the long-term recency effect is limited to two or three items (e.g., Glenberg et al., 1980, fig. 1, 2, 3, 4 and 5; Whitten, 1981,

fig. 1).

There are, however, two strong arguments against a short-term store view of the long-term recency effect.

3. The temporary buffer store hypothesis cannot explain why pronounced long-term recency effects are obtained in incidental learning tasks, where subjects do not suspect the recall test and therefore have no reason to engage in any special rehearsal activity. Baddeley and Hitch (1977) showed a large long-term recency effect in a continuous distractor task, when subjects were required to solve anagram-words. Similar findings were also reported by Glenberg et al. (1980) in an incidental task with the continuous distractor paradigm.

4. The temporary buffer store hypothesis can not account for the list recency effects that have been observed in a final free recall test (Bjork and Whitten, 1974). It seems highly unlikely that subjects engage in rehearsal of list "n-1" during the presentation and recall of list "n".

In summary, it seems that the strength of Poltrock and MacLeod's (1977) argument is not due so much to their claim that a temporal rehearsal buffer or short-term store can account exclusively for the existence of long-term recency effect in the continuous distractor paradigm. The thrust of their argument was to point out that rehearsal activity of the terminal items during the retention interval is possible and can contribute to the long-term recency effect. It seems to me that such claim is perfectly reasonable; it has been suggested by others before in very careful designed experiments (e.g., Reitman, 1974; Brodie and Prytulack, 1975)

and secondly, it is a useful point to take into account when designing experiments with the continuous distractor paradigm.

2.3.5. Retrieval hypothesis

Bjork and Whitten (1974) firstly suggested that long-term recency effects could be due to retrieval processes, since their experiments did not support a storage process. They argued that recency was not a storage process, since any differential encoding of the terminal items during each list presentation was not reflected in either a recognition test or in a final total recall. In addition, recency is found in an incidental learning task, where it is unlikely that subjects anticipate the end of the list, or devote larger amounts of attention and effort to the terminal items.

A retrieval account of recency has already been suggested for the standard free recall task, as reported in the previous chapter. Primacy and recency were explained in terms of by higher accessibility of the ends of the list, which acted as anchor cues for retrieval (e.g., Roediger and Crowder, 1976; Shiffrin, 1970) in terms of the availability of specific cues associated with early or terminal points of each list (e.g., Tulving, 1968).

Retrieval based on a subject selected strategy or on a task anchor mechanism have been referred to account for the long-term recency effect in the continuous distractor paradigm. The former perspective is closer to recent views of the retrieval process, claiming that at the time subjects set

up a memory search they generate retrieval cues, which once matched to memory codes, recover the information required (e.g., Norman and Bobrow, 1979; Raaijmakers and Shiffrin, 1981). The latter perspective implies a more passive view of the subject's cognitive retrieval process by stressing the accessibility of the item near the ends of the list, which prime specific search sets (e.g., Whitten, 1978).

2.3.5.1. Contextual-temporal hypothesis

Glenberg et al. (1983) proposed that long-term recency effects result from the use of contextual-temporal retrieval cues. In particular, they assume that the representation of the experimental context (e.g., the room, the subjects goals and perceptions of the experimental task), is recorded in episodic memory and associated with the to-be-remembered information. The cognitive representation of the context is assumed to change over the course of the experiment. Some aspects of the context such as local contextual components (e.g., subjects fleeting thoughts induced by the changing stimulus array), are assumed to change quickly and become associated with a small set of to-be remembered items. Global contextual components (e.g., subjects guesses as to the purpose of the experiment) change more slowly and become associated with a larger number of to-be remembered items.

In the absence of explicit retrieval cues, the contextual components available at the recall test are used to

cue recall the to-be-remembered items with which they are associated. The local contextual components available at the test are those matching the end of the list. These components are not overloaded, because they are associated with few to-be-remembered items, so they cue the recall of the last few to-be-remembered items and generate the recency effect. The local contextual components associated with the middle list to-be-remembered items are not available at the time of recall. Middle list items must be retrieved through the global contextual components that are associated with many to-be-remembered items. Because the global components are overloaded, recall of middle list items is poor.

The contextual-temporal retrieval hypothesis accounts for the long-term recency effect with different interpresentation interval lengths in this way. The number of components in the list is a joint function of interpresentation interval (IPI) and the retention interval (RI) values. As the interpresentation interval increases, the items in the list are encoded in more different contexts, with more context components associated with each to-be-remembered item. As the retention interval increases, the number of context components that are available at the recall test decreases. Thus the ratio of IPI / RI is "a measure of the number of relevant components, that is, the number of components differentially associated to to-be-remembered items and available at the test" (Glenberg et al., 1983, op. cit. p. 253).

According to Glenberg et al. (1983) the contextual

retrieval hypothesis can account for the long-term recency effects only if two conditions are met, (1) no other retrieval cues other than the test context are available, and (2) interassociations between to-be-remembered items are prevented.

It can be argued that the contextual-temporal retrieval hypothesis is an ad hoc version of the encoding specificity principle (e.g., Tulving and Thompson, 1973) and the cue overload hypothesis (e.g., Watkins and Watkins, 1975). The encoding specificity principle states that recall performance is higher with congruent contexts between learning and recall test than with incongruent contexts. In addition, the cue overload hypothesis claims that a retrieval cue loses its effectiveness to activate items in a list, as the number of items it subsumes increases. Thus the middle list items are more difficult to retrieve, because the relevant retrieval cue is overloaded with several local context components.

Some of the deficiencies of the contextual retrieval hypothesis were discussed by Glenberg et al. (1983). One of the conceptualization deficiencies of this hypothesis is the failure to specify the relations among successive contextual components, as Glenberg himself recognized. Contextual components are an attractive idea, but unless they are operationally defined they do not help very much in our understanding of the long-term recency effects.

The major deficiency of the contextual retrieval hypothesis is its restrictiveness as an explanation. Glenberg et al. (1983) only claim that such an hypothesis can account

for the long-term recency effects in the continuous distractor paradigm. Such explanation does not account either for recency effects in the standard free recall paradigm, or for any other serial position effects. Even the long-term recency effect for personal events, observed in incidental learning tasks, can not be the result of congruent contexts between terminal items and test context, because the reinstatement of the learning context is very unlikely.

Finally it seems that a theory to explain long-term recency effects should be more general in nature and scope in order to account for recency effects in several different tasks.

2.3.5.2. Temporal order discrimination hypothesis

The temporal order discrimination hypothesis claims that the ends-of-list items are perceived more distinctly, are more discriminable and are therefore more accessible than middle list items. Baddeley and Hitch (1974, 1977) claimed that the recency effect observed in the standard free recall task, in the continuous distractor paradigm, and in incidental tasks could be the result of an ordinal retrieval strategy applied to any memory store. When subjects are faced with any set of items, with minimal organization attached to them, they tend to rely largely on the ordinal retrieval cues for the last presented items. According to Baddeley and Hitch (1977) "such strategy is very widely applicable, and probably crucially important in keeping track of events and avoiding

disorientation in a complex world" (op. cit. p. 665).

Why are the temporal ordinal cues more accessible for the terminal items? Firstly, any answer based upon the higher accessibility or better perception is a circular argument: terminal items are better recalled, because they are better perceived and thus are better recalled and so on and so forth. Baddeley and Hitch (1977) got away with such circular argument by invoking a general evolutionary cause: by keeping track of the last events, human beings could avoid disorientation on time, and then improve their chances of success. A species that often misinterprets the order of events in its environment has a smaller chance of success in evolutionary terms.

Whitten (1978) argued that temporal order could account for serial position effects, if three postulates were met, (1) order information is more accessible for ends-of-list items than for middle list items; (2) access to temporal order facilitates recall but not recognition; (3) temporal order deteriorates at a faster rate than item information.

The first postulate accounts for the emergence of recency effects obtained in such laboratory tasks as the standard free recall, continuous distractor paradigm and incidental learning tasks due to order cues being more accessible and discriminable at the ends-of-list than at the middle of the list. List recency could also be explained by the same order cues. The absence of recency in recognition tests may be due to the copy cues provided have overcome the strength and usefulness of the order cues. The absence of

recency in a total recall test of all items plotted for input position could be due to the faster deterioration of order information from the ends-of-list items.

2.4. Overview

Throughout this chapter recency effects obtained in long-term memory tasks were mainly dependent on three experimental conditions:

1. Disruption of interitem associations. This is obtained either by filling up the interpresentation interval (IPI) and retention interval (RI) with a distractive activity, or by using an incidental memory task, where it is assumed that rehearsal activity is disengaged, or by a combination of both procedures.

2. The values of the IPI/RI ratio. If the length of the retention interval was disproportionally large relative to the interpresentation interval, the likelihood of a recency effect was much smaller.

3. The recall test. Under laboratory conditions, long-term recency effects have not yet been reported with recognition or cued recall tests where explicit retrieval cues are given to subjects. It is assumed that the cues provided in the latter memory tests circumvent complex retrieval processes and facilitate the retrieval of middle list items. However, this is not the final word and Chapter four will report long-term recency effects for naturalistic data

obtained with a recognition test.

As far as the interpretations of the effect are concerned there is some consensus that long-term recency effect implies a retrieval rather than a storage mechanism. If this interpretation was so clear-cut I would not take pains to report other interpretations. That was done, simply because those interpretations can explain some of the overall improvement for the last few items in a sequence. Yet they remind us that long-term recency effects are a more complex phenomenon that it appeared at first sight.

Thus at this stage and after assessing alternative explanations and pinpointing some of main shortcomings for all interpretations, the cause or causes of the recency effect are stil not clear. And some important questions still remain: If long-term recency effects are a retrieval phenomenon based on order cues, are the order cues encoded with the items? If so, which persist longer in memory, the order cues or the information? If the information is available can the order of occurrence be retrieved? Or in contrast are the order cues the result of a specific search set allocated to the ends of a list? If the search set is allocated to any other segment of a series of discrete events will such segment be retrieved as better as the ends of a list?

Finally how can researchers be sure that subjects do not rehearse if the continuous distractor paradigm is used, or how can they be sure that the long-term recency effect is not partially due to the strength of the memory traces if an

incidental memory task is used? This seems to me an important paradox that will go on to be raised whenever the continuous distractor paradigm is used in the laboratory.

Some attempts to find out answers to these questions have been made. In the next chapter we will report some of the findings obtained with a new task that may throw further lights on recency and temporal order.

CHAPTER 3: RECENCY JUDGEMENTS

3.1. Tasks and Major Findings
- 3.1.1. The continuous study-test procedure
- 3.1.2. The within-list procedure
- 3.1.3. Serial position judgement task
- 3.1.4. Between list procedure

3.2. Interpretations of Recency Judgements
- 3.2.1. The trace strength hypothesis
- 3.2.2. The time-tag hypothesis
- 3.2.3. The contextual-temporal hypothesis
- 3.2.4. The contextual association hypothesis

3.3. Overview

SUMMARY

Chapter three discusses recency and lag judgements and supplementary information on temporal coding will be mentioned as well. The main empirical findings will be described from the tasks and procedures that attracted most interest among investigators over the years. Those explanations that are still regarded as adequate to account for experimental data will be reported and discussed.

Recency Judgements

Most experiments in verbal learning and memory require the presentation of a series of events distributed over some temporal interval. Temporal factors are usually crucial in specifying what should be recalled, hence understanding how such temporal information is coded is an important step toward the understanding of memory (e.g., Tulving and Madigan, 1970).

In a memory study involving the relative dating of events, there are two critical intervals. Assuming two target memories, M1 and M2, then the important intervals are the interval between M1 and M2 (lag judgements), and the interval between M2 (i.e., the most recent of two events) and the point in time at which the test is given (recency judgements).

For some, lag judgements are regarded as absolute judgements of recency, since the important decision is to judge how far back in the series M1 and M2 were presented in order to determine the number of intervening events occurring between them. On the other hand, what are called recency judgements may be considered as relative judgements of recency, since the important decision is typically to determine which of two events, M1 and M2, occurred more recently in time. However, such distinctions are not as straightforward as they look, they are somewhat task-dependent, and a considerable number and variety of tasks have been used to investigate temporal order. However, whenever possible, the terms lag and recency judgements will be used.

3.1. Tasks and Major Findings

Several tasks and procedures have been used to study lag and recency judgements. In general the tasks may be divided into within or between list temporal order judgements (*).

3.1.1. The continuous study-test procedure

In this task subjects are presented with a long series of words and periodically during the presentation, they are asked for recency judgements on pairs of words. This task was devised by Yntema and Trask (1963). In the second experiment of their study subjects were presented with a deck of 220 cards which they turned over one by one, putting each card face-down before looking at the next. About half were inspection cards; on each of these there were two words, typed one above the other, which subjects had to read silently. The other cards were question cards. There were two words typed side by side with a large red question mark below them. Subjects attempted to judge which of the question words they had seen more recently in the list. The lag since the original presentation of the target word was systematically

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(*) According to Tzeng and Cotton (1980) the term temporal coding can be interpreted in three different ways: (1) coding an item's position in a serial list; (2) coding order relationships among list items, and (3) coding information about an item's presentation duration. The focus of this chapter would be on the first and second interpretation, although some references would be made to the third one.

varied.

Two sets of words were used. One was a set of 259 concrete nouns that seemed likely to evoke good visual images. The other was a set of 259 abstract words chosen with the hope that they would be more difficult to recognize.

The results showed that subjects could judge the relative recency of the test words with reasonable accuracy. If one item has just been presented, subjects were 100% correct, even if the other pair had a lag of four items. When an item was new (e.g., it was not included in the deck) then a target word was judged more recent 75% of the time even with a lag of 136 items. If the lag between two words was constant, the more recently the pair was presented the better was the decision. So while performance was not perfect, temporal discrimination was reasonably good.

Thus Yntema and Trask's experiment revealed that recency judgements were better: (1) the longer the interval between the initial presentation of two test words; (2) the shorter the interval between the presentation of the more recent of the two words and the presentation of the test; (3) with concrete rather than abstract words, as was expected.

Yntema and Trask (1963) introduced the term "time-tag" and suggested that temporal coding must have been laid down at the time of presentation. Using a similar procedure, Wolf (1966) replicated these findings with nonsense syllables and Fozard (1970) with pictures.

In another procedural version, subjects may be

presented a limited set of items which are used over and over. On the presentation of each item subjects must estimate the number of items presented since its last occurrence (e.g., Hinrichs and Buschke, 1968). In this experiment subjects were presented with eight different sequences of 250 items. The items were the eight last letters of the alphabet, except "V" and "U" to minimize visual and acoustic similarity. Thus if the letter sequence was [RTWTTSRWR], then the correct lag judgement was [000210652]. There were 15 different lags.

Hinrichs and Buschke (1968) found that the mean judged lags were a negatively accelerated increasing function of actual recency, with the proportion of perfect recency judgements declining from 100% for one lag to chance performance after about nine intervening presentations. They further pointed out that the probability of correct judgment as a function of the lag bears a strong resemblance to typical retention functions from time perception experiments involving an estimation procedure (*).

3.1.2. The within-list procedure

In this procedure supra-span word lists are presented for study and, at the end of each list, subjects are given pairs of words from the list and are asked to choose the most recently occurring word in each pair. In addition to recency

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(*) In particular, a typical result in time perception studies is overestimation of the duration of short intervals and underestimation of long intervals (e.g., see Allan, 1979 for a review)

judgements, subjects can be asked to make lag judgements (e.g., about how many items intervened).

In the second experiment reported by Underwood (1977) both recency and lag judgements were requested. Subjects were presented with four successive lists of 32 four-letter words. After the presentation of each list, 12 recency judgements with lags of zero, one, five and 10 were required. Twelve pairs of words were presented and the subjects' task was to choose the most recently presented word in each pair. In addition to each recency judgement a lag judgement was required in which subjects circled a number from zero through 14 to indicate the number of words believed to have separated the two words in the list.

The results indicated that recency judgements were in an absolute sense quite poor (about 60%), although they improved as a function of the lag length. Thus the closer two events are in time the greater the probability that an error would be made in a recency judgement. On the other hand, the results from lag judgements indicated that short lags were overestimated as usual, while long lags were underestimated. That is, if the real lags were three and twelve, subjects were more inclined to respond four to the short-lag and ten to the long one (e.g., Wells, 1974).

This paradigm has been used in several other studies to investigate the effects of frequency and repetition (e.g., Hintzman and Block, 1971), the cumulative rehearsal of items (e.g. Tzeng, 1976; Tzeng, Lee, and Wetzel, 1979) and the contextual associations produced during the study-phase (e.g.,

Tzeng and Cotton, 1980).

3.1.3. Serial position judgement task

In this task a list of supra-span words is presented for a study trial, after which subjects are asked to identify the position held by each item in the list. Following this procedure, Underwood (1977, experiment 4) presented 25 words, each for five seconds, and then asked subjects to identify the position held by each word in the list. After the list was presented, test sheets were distributed with all 25 words listed in random order. Subjects were required to assign to each word a number that represented its original position in the list.

Results indicated clear primacy and recency effects. The first, second and third words were assigned a correct position by 97%, 89% and 60% of all subjects respectively. On the other hand the terminal three words, 23rd, 24th and 25th, were correctly located by 14%, 38% and 58% of subjects. The asymptotic level was between 15 and 20 percent.

Serial position judgements were obtained before by Schultz (1955) in a standard serial learning task and by Underwood (1969). All these data seem to suggest that subjects store serial position information, and the word-position is a cue in multitrial serial learning and free-recall.

3.1.4. Between list procedure

In the between list procedure, subjects are asked to identify the list membership of the items making up each separate list. Underwood (1977, experiment 3) had subjects learn three successive lists of 20 words. Materials were four-letter words and were exposed for two seconds each for study. Subjects were instructed about the type of test to be given at the end of the session. To test between-list temporal judgements, the 60-words were printed in a random order on a sheet of paper. The numbers one, two and three appeared after each word and subjects' task was to circle the number representing the list in which the word had occurred.

The results indicated that correct list assignments varied from between 50 to 55 percent. The correct assignments were greater than would be expected by chance (33%), although in absolute sense memory for the temporal order of these three lists was poor.

In two other experiments, Underwood (1977) manipulated the effects of context in order to examine how it could mediate temporal ordering of list-events. In the first of these (experiment 13), subjects learned four successive lists of 16 words each. The words were of low frequency and contained two-syllables. At the end of the fourth list presentation, subjects were asked to indicate the list membership for each word in all the lists.

The context was manipulated by integrating each list

into a different verbal learning task. Thus some groups had all four lists presented in different task contexts: a verbal-discrimination list, a paired-associate list, a serial list and a free recall list, while other groups had only one of these tasks throughout the experiment. In addition to these learning task contexts, list numbers (1,2,3,4) occurred several times during the presentation of each list. Three acquisition trials were given for each list.

The main reason for such information redundancy was to provide a potential ordering system and to maximize the possibility of establishing associations between list number, words within the list, and task content. It was assumed that these associations would be less well established when the task context was the same across lists than when it was different.

Thus the design of the experiment included six conditions, four representing similar contexts (i.e., one based on each of the four tasks) and two representing different contexts. The two different contexts involved two different ways of randomizing the four verbal tasks. After the third trial of the fourth list, each subject was given five minutes to work on a pyramid puzzle and then unexpected instructions for list identification were given.

The results indicated that overall there were significantly fewer errors under the two different context conditions than under the four similar conditions indicating that the varied verbal learning task context facilitated temporal discrimination.

Despite this significant difference, Underwood was puzzled by the large variance shown in the different context group. He therefore divided subjects from different context groups into two groups, one with high and one with low variance scores. When the scores of these groups were analysed and compared with the results of similar verbal learning task context groups, it became clear that half the subjects in the different context group were markedly influenced by the context manipulation, while other half were not influenced at all. That is, the scores of the latter subjects were equivalent to subjects running under similar context conditions.

Two other findings from this experiment are worth pointing out: firstly, the mean number of errors was smaller for the first and fourth list than for intermediate lists in all but one condition; secondly, when scores of the serial recall learning task context group were compared with their own scores for list identification, the correlation obtained was [$r = -0.15$]. This result supports the view that the probability of an item being correctly identified with its list on a temporal order test is not related to its probability of being correctly recalled.

In another experiment (experiment 14) Underwood (1977) tried to determine if two types of context (semantic and external) would summate or interact in any way in their influence on temporal coding. Semantic contexts were induced by selecting all words in a list from a single taxonomic

category, with eight different categories represented by eight lists. External contexts were made up using eight different tasks, each given to subjects for 90 seconds, one after each of the eight free-recall lists. The external context tasks selected were symbol cancellation, anagrams, arithmetic, stroop task, two different search tasks, alphabet printing, and mirror star tracing.

The final design of the experiment included six groups, representing a factorial combination of the three variations of the external context, same (S), different (D), and none (N), paired with two semantic context conditions: unmixed (U) context, where all words in each list were instances of the same category; mixed (M) with one word from a different category appearing in each list. Each eight-word list was presented for two study trials at a 2-second rate with a different order of words on each trial.

Contrary to Underwood's other experiments, list numbers were never used to identify lists and subjects were unaware that they would be tested for their knowledge of list membership of the items. Therefore the learning of temporal order was incidental. According to Underwood (1977) if a "calenderlike ordering device was to develop, it had to be supplied by the subject" (op. cit. p. 119) for determining temporal order.

The results showed that, across all eight lists, the mean number of list identification errors was smaller for unmixed than mixed semantic content lists. In addition to the first and last unmixed lists, list identification was almost

perfect, with words assigned more than 90% to the correct categories. Some subjects also had information about the second and seventh list, but beyond this reasonably good temporal coding, performance for the remaining lists was about chance. In contrast, the mean number of errors for the first and terminal mixed lists was about 50 percent. These results demonstrated that semantic context influenced temporal coding for the initial and final lists, but beyond this, its influence was of little consequence.

As far as external-context tasks were concerned, they had no influence on temporal coding. Underwood (1977) confessed that there was no necessary reason why external or procedural context should have influenced the temporal coding of the word lists. In his own words "even if subjects said to themselves, ""Oh, that word is from the list that came right after that mirror-tracing task"" they in addition would need to know where mirror tracing came in the series of eight tasks, if the word was to be correctly identified with its list" (op. cit. p. 125).

Thus far, studies on temporal order and recency judgements have shown that:

1. Within a sequence of items, position judgements are reasonable good with accuracy increasing for primacy and recency items. If a long list of words is presented and subjects are asked to assign a word to its input position on the list, results have shown a clear relationship between true position and position judgements (e.g., Toglia and Kimble,

1976; Underwood, 1977).

2. Within a sequence of items decisions about lag judgements are not usually above chance level. Thus if pairs of items are randomly selected from a list and subjects asked to determine how many items intervened between the two, no relationship was evident between judgements and true lag (e.g.,Hintzman, Summers, and Block, 1975; Underwood, 1977). Such results seem a paradox. On one hand, subjects are able to make reasonable good reliable position judgements within a list, on the other hand, they seem unable to compute the number of intervening items, that separate both targets.

3. The relationship between lag and recency judgements seems to depend upon the method used. In the within list procedure, correct recency judgements are not substantially affected by lag length. That is, performance increments are much smaller than lag values, (e.g., Underwood, 1977). In contrast, recency judgements have been shown to depend largely on lag values in the continuous-study test procedure (e.g., Yntema and Trask, 1963; Peterson, Johnson, and Coatney, 1969; Hinrichs, 1970).

4. The effects of semantic context are substantial, but largely restricted to primacy and recency . In contrast, manipulations of external context have not interacted in any significant way with temporal coding in experiments reported thus far.

Defining recency judgements as the ability of an individual to judge the recency of occurrence of an event in a

sequence of similar events, one may ask how is it possible to judge the relative or absolute occurrence of events? The dating of most of one's past memories undoubtedly occurs from reconstruction (i.e., by reference to other memories and known logical relationships). From past experience as well as from our daily life we can very often deduce temporal order, because of the external context and the characteristics of the events in question (e.g., from the few occasions I have been to London, I remember that I visited the British Museum before visiting St. Paul's Cathedral, because I was together with different friends on each occasion. Meanwhile I remember that I never been to London again with the friend with whom I have visited the British Museum).

In contrast when the logical cues, context and sequential relationships, which guide perception of time are minimized (e.g., as in a list of words or in the sequence of seven deadly sins, the ten Commandments or the colours of the rainbow), how is recency judged? The importance of the Yntema and Trask (1963) study was to show for the first time that temporal order could be discriminated in a memory experiment without any external temporal cues.

3.2. Interpretations of Recency Judgements

From the experiments described so far one may ask what are the mechanisms underlying the temporal coding of events? Several explanations have been put forward in the past to

account for the the data. A review of the main interpretations will be reported next.

3.2.1. The trace strength hypothesis

This hypothesis assumes that the strength of the memory trace for an item or its order position within a sequence decays with time. Thus recency judgements are based on the discrimination of different strength amplitudes among traces (e.g., Morton, 1968; Hinrichs, 1970). Hinrichs (1970) put forward the major formal model within the trace strength hypothesis. According to his model, subjects do not store temporal information in memory. They simply infer the recency of items by comparing their respective trace strengths. Assuming that trace strength of an item is a decreasing exponential function of elapsed time, or the number of intervening items (e.g., Hinrichs and Buschke, 1968), then the stronger the trace of an item, the more recently it will be judged to have occurred. Therefore the model assumes that recency and temporal order information is a cue derived at the time of the judgement task.

The difficulty with the trace strength hypothesis is that operations that presumably strengthen the traces (e.g., item duration, repetition of items and context), do not produce predictable changes in temporal judgement. For example, Morton (1968) found that a repeated item was not judged more recent than a comparable item presented only once. Underwood (1969) found that recall was better when items were

presented for longer durations, but the accuracy of temporal estimates were independent of the level of recall. In a strict sense this can not be true. As Underwood (1977) pointed out, an item must be exposed for some minimal amount of time for a temporal code to be established. The evidence indicates, however, that beyond this unknown minimal amount of time, further exposure does not add appreciably to the temporal code (*).

Meanwhile trace strength supporters claim that the trace strength model of recency judgements has been mainly developed for situations in which exposure, repetition and contextual cues are minimal. They claim that, when contextual information is minimized, strength of the memory trace is sufficient to discriminate the relative recencies of test items.

In summary, it appears that the robustness of temporal codes derived both from incidental tasks or small amounts of exposure is an automatic process. Temporal codes can exist as a memory attribute, but they seem independent of the so-called trace strength. However, the automaticity of temporal coding is not accepted by everyone. In a summary of this chapter we

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(*) Tulving and Madigan (1970) severely criticized the strength hypothesis in a suggested thought experiment. If subjects are presented with a series of items, being one of which the subjects own name or some other conspicuous item, and then tested for recall of all items, it is high likely that all subjects will remember seeing their own name. Thus the trace strength of the name must be very high, possibly higher than any other item. If in a recency judgement test, subjects estimated that their own name was the last in the series, then Tulving and Madigan advised the prospective author to write immediately to "Science" or "Nature"!

will have something more to say about the automaticity of temporal coding.

3.2.2. The time-tag hypothesis

Yntema and Trask (1963) introduced the term "time-tag" and suggested that the temporal coding must have occurred at the time of presentation. In order to explain serial position effects, Bower (1967) suggested that "time-tags" are assigned to ends-of-list items. Tulving (1968) reinforced this interpretation, by claiming that temporal dating of items by subjects during input could constitute an auxiliary retrieval cue at recall. Being particularly concerned with the temporal order of words from a single free recall list, Anderson and Bower (1972) assumed that temporal order could be remembered through the use of covert verbal labelling (e.g., a list could be subdivided into early words, middle and last words). These verbal cues could be included as part of the encoding for each word. Some support for this interpretation could be obtained from subjects verbal reports about the strategies used during an experimental session (e.g., Underwood, 1977, experiment 4).

Although the attribution of temporal order to verbal cues can account reasonably well for the laboratory data, with lists of previously known length (otherwise how could they attribute a middle item time-tag?) it may not explain the ordering of the events occurring outside the laboratory, which all have presumably been labelled as "occurring today", or not labelled at all. However, it might be argued that for

instance the last two visits to the bank or the coffee bar today were not only labelled as "occurring today", but one as "last time I went to the Bank or to the coffee bar". After all this is a circular argument, because all events were labelled as the "last time I did so this and so that".

A variant of the "time-tag" hypothesis is the absolute "time-tag" hypothesis, or the so called the "tape-recorder" or "conveyor belt" model, Murdock (1972). The model assumes that our experiences are somehow stored in an ordered sequence, based on their order of arrival. Such a model would explain Yntema and Trask's (1963) results in the following way. When a test card is presented, the subject begins to search the encodings in order, starting from the present and going backward into the past. Therefore the item that is found first is the most recent item.

The "tape-recorder" model assumes that encoding an item adequately enough for recognition or recall ensures that the memory trace is laid down in appropriate temporal order. Therefore if an item is recalled or recognized at all, its temporal position is automatically known. In fact it has been shown that subjects are capable of recalling or recognizing items without being able to designate their temporal position (e.g., Winograd, 1968; Underwood, 1977, experiment 13; and experiment three of this dissertation).

Another problem with the absolute "time-tag" hypothesis is that it predicts a high level of performance. In addition and without further postulates, the model can not

account for discrimination difficulties of recency as the items become less recent. In the Yntema and Trask (1963) study discrimination became more difficult as the recency of the pair of items decreased. If item A has been just presented, then item A was always chosen correctly, even if the other item of the pair, item B, had a lag of four items. However, if the lag of A was four and B was eight items, then A, as the most recent item, was chosen correctly only about 70% of the time. Thus a lag difference of four items in both conditions became more difficult to discriminate as the items became less recent.

A further problem with the strength model and the time-tag models is the finding observed in the serial position judgement procedure that subjects remember better the temporal information of primacy items than middle list items. Yet either model can account for the finding that words assigned to the wrong list, in a series of lists, still tend to be placed in the correct within-list position (e.g., Hintzman, Block, and Summers, 1973).

3.2.3. The contextual-temporal hypothesis

Weisberg (1980) put forward an alternative explanation of recency based on reconstructive time. Briefly, Weisberg (1980) claimed that memory for temporal order is derived from encoded cues, but it is not directly represented in these cues. In other words temporal order is derived from the information perceived, but no "time-tags" are attached to item

information. From this perspective recency would be reconstructed from the cues by comparing them to some reference point. According to Weisberg (1980) perhaps "memories are scaled for recency by comparing them in some way with how things are now. The memory which is most similar to the way things are now, in some yet-to-be-specified way, is the most recent memory" (op. cit. p. 74).

Thus a time scale or temporal order may be obtained by comparing items according to their similarity to the present. This model requires further clarification. First, what is the nature and duration of the "present" as a reference point? Is it today? The last few hours or the last few seconds? Secondly, if memories can be more or less similar, what is the nature of the changing factor that makes memories less similar to the present?

Weisberg's answer to these criticisms is not very different from the Glenberg et al. (1983) contextual temporal retrieval hypothesis described in the previous chapter. Weisberg (1980) defined the psychological moment, as a more or less rapidly changing state due to brain and bodily changes, which can be conscious or not. This psychological present, with all the background changes, can act as a reference point to which past memories are compared. In addition, and due to different background contexts in which items are encoded, the farther apart the encodings occur, the more their backgrounds will differ from the psychological present.

Several studies have shown that the state of the organism is encoded with the items during an experiment,

whether state is manipulated in terms of posture (e.g., Rand and Wapner, 1967), external environment (e.g., Godden and Baddeley, 1975) or bodily and organic state (e.g., see Eich, 1980, for a review). These studies indicate that some aspect of a subject's psychological state or context is incorporated into the memory of the events. However, unless a more careful specification of contextual components, tags, or item attributes is given, a contextual interpretation offers no more than an attractive but empty concept.

3.2.4. The contextual association hypothesis

According to Tzeng, Lee, and Wetzel (1979) the reference point for recency judgements is not the present, but the beginning of a series of events. These investigators assumed that temporal order is established through incidental learning resulting from the study-phase retrieval of the prior items at the time of encoding the current item. That is to say, if a subject remembers item A at the time of encoding item B, then the mere fact that he remembers A while learning B implies that A must have occurred before B. By keeping the earlier words active in their working memory by continually rehearsing them (study-phase rehearsal), while processing the current item, the temporal coding becomes an inevitable (or automatic) consequence of memory.

In addition, Tzeng et al. (1979) argued that the concept of a "beginning" item, the primacy effect, will have a constant and absolute meaning, whereas the concept of a

"current" item is destroyed as soon as the next item is presented. Putting "latest" as a "time-tag" code to a currently processed item is not very useful. Thus according to Tzeng et al. (1979) marking the past is more important than marking "currency" in temporal coding.

The first postulate of the contextual association hypothesis emphasizes the availability of the prior items in the establishment of temporal codes. The second postulate leads to the assignment of unequal weights to the two end points of a serial list. Since only the beginning items have temporal codes in an absolute sense, the prediction is that only beginning items can serve as anchor points in temporal judgement.

Since the primacy effect was one of the most damaging pieces of evidence against the strength and time-tag models, in Tzeng et al. model, the primacy effect is a natural prediction. The claim they made is that subjects during the presentation of the first few items presented in a laboratory task experience the most dramatic change in contextual cues.

3.3. Overview

In this chapter some general issues related to processing and encoding of temporal cues and some others specifically involving recency judgements were presented and several interpretations given. In an overview, I would like to address the isssue of automaticity of temporal coding, the

relation of temporal cues to context information and the reference point for recency judgements.

Firstly, the long adopted view of automaticity of temporal coding (e.g., Zimmerman and Underwood, 1969; Hasher and Zacks, 1979; Tzeng, Lee, and Cotton, 1979) has been challenged in a series of studies summarized recently by Michon and Jackson (1984). These investigators argued that temporal coding involves deliberate rather than automatic processing, since manipulations of experimental variables, such as instructions, level of practice, developmental trends, the features of materials selected, levels of processing and context, have a significant influence on memory for temporal coding.

Secondly, there is a fair amount of consensus among contemporary investigators that temporal information is related to context. However, there is still a clear lack of understanding of what exactly constitutes a temporal cue, which factors facilitate its encoding or the disruption of its processing, and why subjects under identical task procedures encode or ignore the effects of context.

Thirdly, and contrary to Tzeng et al., recency judgements certainly depend on the present as a reference point for temporal order discrimination. Whether or not the present is today, the past hour or the past minute, it remains open for discussing. However, it seems that the psychlogical present is not an entity with an absolute size. It depends greatly on the interpresentation interval between to-be-remembered events. It could be the last minute, hour or

day, provided that the other events in question occurred in units of minutes, hours or days in the past.

Finally, the position that the present is the reference point is not totally incompatible with the view that the first item in a series of events or a striking item occurring in the past can have a similar role. Assuming that this may be so, then the Tzeng et al. (1979) hypothesis could be saved as a contribution to extend the processing of temporal order cues to the beginning of a sequence of items.

CHAPTER 4: NATURALISTIC MEMORY STUDIES

4.1. A New Outlook in Memory Research
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- 4.1.2. Reasons for a new perspective
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- 4.1.4. Another fashion or a new outlook

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4.4. Recency Judgements and Temporal Order
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4.5. Overview

SUMMARY

A new outlook on memory research stressing the need for investigating the external validity of traditional memory studies will be presented and its implications estimated. Then an account of some techniques to elicit everyday memory contents and their major shortcomings will be considered in some detail. Finally naturalistic memory studies with implications for the study of serial position effects and temporal order will be described and commented.

4.1. A New Outlook in Memory Research (*)

4.1.1. Traditional and naturalistic memory studies

Since the beginning of the 1970s there has been a growing concern among some experimental psychologists working on memory about the external or ecological validity of the experiments carried out in the laboratory. For several decades learning and verbal memory studies followed the Ebbinghaus and Pavlov approaches, which stressed the importance of laboratory control over critical variables. Ebbinghaus (1885) invented the nonsense syllable in order to control the effects of familiarity, meaningfulness and frequency, which it was assumed would have a large effect on the variables under study. This preoccupation with strict control over the type of materials being presented was extended to the subjects selected for the experiments. Human beings, even if they were undergraduates of a top university with equivalent cognitive skills, were expected to differ in personality, motivation, health states, food and drug intakes

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(*) Very often in the literature the words "naturalistic", "autobiographical" and "everyday" memory studies are used almost as synonymous. Yet, I would like to stress that "autobiographical" memory is a chronicle of one's past experiences and episodes, not necessarily shared with other people; "Everyday" memory comprises mainly external episodes that are shared by a group, community or even nations. In autobiographical memory the stress is on the individual content of past episodes, while in everyday memory the stress is on shared contents. Naturalistic memory is a superordinate concept for the two previous categories, focusing on researchers attempt to increase the external validity of laboratory research.

and so on. Therefore better than undergraduates to serve as subjects in a verbal learning or memory experiment were rats whose genetic constitution, learning history, internal body states and external environment could be kept constant to a great extent.

The emphasis on laboratory control over critical variables incorporated the wish among psychologists to apply the experimental method to the study of higher cognitive processes. The experimental method was the corner stone of the established sciences in the 19th and 20th century. The method had been applied to psychophysics with great success, and psychologists in general became very interested in achieving scientific status for their research. Setting up psychological laboratories and following up the requirements of the experimental method in a larger number of research areas became one of the major priorities for psychologists in the first decades of the present century (*).

However, a century of research on learning and memory, using nonsense syllables, consonant trigrams and more recently words, did not produce spectacular insights into the workings of the human mind. A few cynics even proclaimed that any 20th century discovery about the human mind was not radically

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(*) Psychology's endeavour to become an acknowledge science was formally successful on 13th September 1982, when the International Council of Scientific Unions (ICSU) voted to admit the International Union of Psychological Science into full scientific membership. Psychology and Geography were in 1982 the only two social sciences to have an acknowledge scientific status. Even Economics, with higher status from the attribution of a Nobel prize was still not included in the ICSU.

different from what Aristotle has already written some 25 centuries earlier. In such disillusioned atmosphere the culprits were regarded as being the type of materials used, the subjects selected, the laboratory and its constrains and less referred but certainly influential the editorial boards of scientific journals and the academic establishments.

4.1.2. Reasons for a new perspective

In recent years investigators have responded to demands that memory research should address problems of cognition as they are encountered in the real world with real people. In this sense, Neisser (1976) asked psychologists to make a greater effort to study the variables that are representative of real people in the real world rather than those that are easily manageable in the laboratory. Baddeley (1981, 1982, 1984) stressed the above recommendations in several studies and articulated some of the reasons why memory studies should extend their scope into the outside world.

One reason would be to check the external or ecological validity of the theories, models and results obtained in the laboratory. For some time researchers have known quite well what was the average recall performance for nonsense syllables, consonant trigrams or words. They knew if there were performance differences resulting from type of presentation, the number and length of lists, and could predict which laboratory memory tests were easier and which harder. There was available major theories of forgetting and

a few models of the human memory system. However, memory researchers would feel very uneasy if asked to give valid advice, for example to the man in the street who wanted to know why he had a poor memory for names, reasonable for jokes and excellent for faces, whereas his wife had a good memory for names and faces, worse for jokes and terrible for digits. Why they both forget birthdays and to keep appointments, but have a good memory for the occasion when they met each other for the first time and the whereabouts of their honeymoon. One of the reasons for such uneasy feelings stems from the lack of general knowledge on individual differences in remembering and forgetting.

Another aim of the study of naturalistic memory was to capture new phenomena in autobiographical and everyday memory and to increase the data pool of memory studies. It was suggested that psychologists ought to test more samples of people from different backgrounds, races and countries; to extend and apply their research skills to a much wider range of situations and to problems that have traditionally being ignored or were unable to be studied in the laboratory. In addition, memory studies have been traditionally concerned with things that occurred in the past. There are, however, circumstances when it is important to remember in connection with future events and the plans for actions that will occur in the future. Examples are the need to remember to keep an appointment with the doctor, to take a medicine every six hours, to post a letter or to buy a stamp, to remember in due course where the umbrella was left or the car was parked and

so on.

Thirdly, there is growing interest in applied problems originating from recent changes in the economic and political climate. Research funds are not only tighter, but there is more competition. The public has become more interested in research and if real problems are tackled and solved, the public is more likely to understand and to support the research done. More and more students are nowadays employed in industry and services, where new applied skills are required rather than the traditional theoretical ones related to an university post.

In addition to the causes just described, it seems to me that psychologists in the 1970s, unlike their colleagues some decades earlier, became less and less worried about the scientific status of their work. The use of the experimental method and the increased sophistication inside the psychological laboratory has brought grater respectability and the products of psychological research have started to influence organizations and decision makers. With greater confidence in the scientific status of their research it became more acceptable to study the messier factors of everyday memory. And some of the proponents of naturalistic memory studies, like Neisser in USA and Baddeley in England, were not newcomers to the psychological research. They had already made a name in the traditional laboratory studies.

4.1.3. Scope and limits of naturalistic studies

This new outlook has recently yielded a large amount of research into everyday memory problems (e.g., Gruneberg, Morris, and Sykes, 1978; Neisser, 1982). The number of papers presented in these books is indeed large. Studies were carried out on memory in everyday life for such issues as medical information, absent-mindedness, urban geography, messages broadcast to the general public, eyewitness testimony and facial recognition; Studies on individual differences and memory in children and in the elderly; Memory under stress and arousal; Memory impairment in brain damaged people; Memory and drugs; Reading and memory and memory and dyslexia; Childhood recollections and flashbulb theories; Memory strategies and mnemonics and the analysis of some mnemonists memory, and much more. The major focus of this research endeavour has been to examine ways in which traditional or recent memory theories and models could be tested for their ecological validity and ways in which such studies could throw light on aspects of theoretical interest and importance.

The theoretical repercussions of these and other studies published elsewhere are still being assessed by workers in the field. But having said that, it does not imply that all naturalistic memory studies are of immediate theoretical significance or can suggest a defined explanatory model. Baddeley and Wilkins (1984) pointed out that flashbulb memory studies about the assassination of president Kennedy (e.g., Brown and Kulik, 1977), or memory descriptions about

the detailed appearance of a penny (e.g., Nickerson and Adams, 1979) could have heuristic value, but they did not advance to any significant extent our knowledge about the cognitive processes.

Indeed some investigators claimed, that it is in the laboratory that the real problems of everyday memory can be most adequately solved. If biological and biochemical research can be taken as a broad analogy, then it can be said that everyday biological problems related to diseases and infections were quite often solved under the artificial conditions produced in the laboratory. Some investigators have stressed that there is no compelling evidence that the principles that apply to the remembering of events in the laboratory should be greatly different from those governing the remembering of real life experiences. In this sense Tulving (1983) pointed out that "remembers do not leave their brains behind, or switch them off, when they enter the memory laboratory (op. cit. p. 146).

4.1.4. Another fashion or a new outlook

Critics of psychology sometimes claim that psychological research goes from fashion to fashion, without making any substantial progress over the years. It is a criticism that investigators should bear in mind when designing experiments or working at the bench. Such trends or "fashions" were very often the result of working with tasks and paradigms that subsequently failed to provide the expected

answers to major psychological issues. The departure from traditional paradigms also occurs in other sciences, where no one doubts that progress has been accomplished.

All in all, the climate of memory research has changed during the past decade and a new outlook has been largely adopted. Memory research has reached a stage where there is a wealth of data and a number of highly sophisticated quantitative models to account for these data. Nowadays almost every investigator agrees for the need to examine memory under other conditions than those that have figured prominently in traditional experiments. Consequently it has become more acceptable to sacrifice some control over critical variables in order to investigate ecologically important, but complex phenomena that would otherwise be neglected. Research on these messier problems has produced a large pool of new data that are of interest to many people, from the man in the street to the psychotherapist and jurist.

Finally, psychologists are nowadays aware that if they want their research enterprise to continue to maintain a scientific status (so courageously established by their senior colleagues) they must maintain a balance between the careful control over the conditions under which people remember things and the need to tackle realistic problems.

4.2. Methods for Investigating the Contents of Memory

Most of the studies to be reported in this chapter on recency and other serial position effects were obtained under

less restricted conditions and involve a wider range of materials and samples of subjects than those referred in previous chapters. Such studies are invaluable, since they largely check the extent to which the experimental results described earlier have external or ecological validity and therefore represent real processes of the human mind at work.

The naturalistic memory studies to be reported in this chapter fall into three broad categories, according to the methods used to elicit the contents of memory.

4.2.1. Prompt-word technique

The first category uses Galton's technique of open-ended associations to each of a series of words. The words selected have usually high frequency and imagery ratings. On each trial a single word is presented and the subject is told to report the first autobiographical episode or recollected event that the word brings to mind.

This technique is known as the "prompt-word" or "semantic cuing" method and has been used in recent years by many investigators including Crovitz and Schiffman (1974) to study the frequency of episodic memories as a function of age and Crovitz and Quina-Holland (1976) to investigate the proportions of episodic memories from early childhood. Robinson (1976) examined the characteristics of prompt-words which regulate the accessibility to memory contents, while Franklin and Holding (1977) studied how different age groups differ in life-span distributions of the memories accessed by

the same prompt-words presented to each group and McCormack (1979) analysed the function relating frequency of occurrence of remembered episodes to quarters of the life-span in elderly subjects.

The prompt-word technique has several advantages: Firstly, the technique allows the investigator to specify a time period from which the autobiographical recollections and everyday episodes are to be drawn; for example childhood or university student recollections.

Secondly, the words can be systematically varied to test on what words can elicit different recollections or incidents involving different emotions. It has been found, for example, that some words tend to prompt younger memories than others (e.g., McCormak, 1979).

Thirdly, the investigator can specify the type of memory to be recalled. He or she may only be interested in single incidents (for example "when I won a cup in the college for being the fastest runner") that can be more easily dated, than recurrent events (I used to run 10 miles a day, when I was in the college).

Fourth, the latency of each recalled episode can be recorded and its value compared for different ages, life-span periods and the contents of memories.

Fifth, this technique can be modified and adapted to different experimental procedures more easily than any other method.

In contrast, several criticisms of the prompt-word technique have been made: Some of the criticisms are general

ones, that apply to any naturalistic method and for that reason they will be discussed later. Some of the more specific criticisms are:

Firstly, some words elicit younger memories than others, therefore some pilot studies must be carried out to control this bias.

Secondly, subjects may recall episodes from particular ages or areas of experience and they may deliberately search for favourable rather than unfavourable examples of their behaviour. A careful analysis of response latencies may uncover such discrepancies, if it is assumed that reaction times covary with the salience of the events and are uniform for one's life-span.

Thirdly, the age and sex of the experimenter may affect the variance of the results obtained, specially when subjects are from different sex and age groups. The variance may be reduced if instructions and prompt-words are presented on a computer terminal.

Fourth, the role of personality and motivational variables in the memory system is largely unknown. There is some reason to expect that personality traces (e.g., normals versus depressed people) as well as motivational variables (e.g., high versus low achievers) would influence the amount and type of episodes for such prompt-words as "car", "visit" or "safe".

4.2.2. Incidental free recall and recognition

The second category of studies has employed the traditional memory tests of free recall and recognition. Subjects are asked to recall past episodes from their lives and external events or to recognize famous faces, personal friends or old acquaintances from a specific time period.

This method was initially employed by Dudycha and Dudycha (1941) who presented a review of earlier autobiographical work. Waldfogel (1948) asked subjects to report and rate childhood memories from birth until eight years old according to several dimensions, for 85 minutes; Riegel (1973) asked university students to recall the names of persons they have met during their lifetime for six minutes; Roediger and Crowder (1976) asked subjects to recall the names of US presidents for five minutes; Baddeley and Hitch (1977) asked members of two rugby clubs to recall the names of rugby teams they had played against that season. Whitten and Leonard (1981) tested students for the recall of their teacher's names from 12 preuniversity schooling years in three different orders; Using a cross-sectional procedure for selecting subjects Bahrick, Bahrick, and Wittlinger (1975) examined the rate of forgetting for the names of the members of each subject's graduating class with recall and recognition tests. Linton (1982) performed an experiment on herself, as the only subject, to investigate the retention and forgetting of episodes over a six year period.

Free recall as well as promt-word methods allow

subjects to recall memories from any specific time period, and to date and rate their memories according to several dimensions, such as salience, vividness, personal or general importance, pleasantness, surprise and rehearsal times. In addition, the same memories can be dated and rated some time later by the same subjects, or subjects can be asked to recall and rate other episodes from the same period. Reliability coefficients between the two sessions or the specific ratings can then be computed.

However, one of the major criticisms of both the free recall and the prompt-word methods is the lack of objective verifiability for the genuine occurrence of the age of the episode remembered. If the prompt-word "river", for example, elicits the description of a sunday morning fishing episode, the age of this episode could be rated as six years old when it was remembered in the first session, or either five or seven years old when the subject was asked again to date the episode one week later. Surely, whether the episode really occurred is also questionable.

Apart from general criticisms that are inherent in all naturalistic memory studies, other disadvantage about the free recall method relates to the time period selected for recalling episodes. If for example subjects are able to recall on average 20 episodes from their childhood in six minutes, when given a prolonged interval, the number of total episodes may be very much superior. When Smith (1952) periodically recalled episodes of her life for several months, she was able to recall over 6000 memories, that were confirmed

when checked against her or her mother's diaries.

4.2.3. Questionnaires

Since the number of episodes in one's life, both personal or shared with other people that can be dated precisely is undoubtedly very small, some investigators have designed questionnaires to examine more precisely the fate of old memories, the rate of forgetting and the speed of retrieving events from different ages. In addition, questionnaires with their planned statements or queries aiming to elicit a specific set of information from a large number of persons, were regarded as a more reliable means of assessing the forgetting of past memories.

In general, the contents of these questionnaires were related to public events, shared by a large number of people and hence verifiable. Warrington and Silberstein (1970) and Warrington and Sanders (1971) compiled a questionnaire with questions relating to salient news events selected from "The Times Review of the Year" during a period from about 40 years preceding the study. Another questionnaire was also prepared with photographs of well known faces covering approximately a 30-year span. Recall and recognition versions of these questionnaires were prepared for testing. Squire, Chace, and Slater (1975) prepared a multiple-choice questionnaire to assess the forgetting function of remote memories for television programs broadcasted for a single season and another questionnaire for the names of winning race horses for

a span of 15 years preceding the study.

Other investigators designed questionnaires where the questions asked were all restricted to a unique single event rather than several events. One of the major purpose of these questionnaires was to assess the strategies employed to remember the circumstances and the context of the to-be-remembered event. In this way Baddeley, Lewis, and Nimmo-Smith (1978) designed a questionnaire to investigate the episode of their subjects' last visit to the laboratory.

The use of questionnaires has several advantages: The information obtained can be checked against objective records; the rate of forgetting, the speed of retrieval and the strategies employed can be studied more precisely as can the role of individual differences related to sex, age, personality traces, or even clinical treatments. Squire, Slater, and Chace (1975), for example, used their television program questionnaire to examine the effects of retrograde amnesia following electroconvulsive therapy.

However, objective memory questionnaires also present problems. Firstly, there is always a danger of involuntary sample bias in selecting the items for the questionnaires, since it is a very difficult task to select questions with equal difficulty over a span of one or more decades. If questions on earlier periods are more difficult than recent ones, then such imbalance can explain performance decrements for the older items. For example such biases have strongly affected the results of some studies (e.g., Squire, 1974). Secondly, news items and famous faces are not always exposed

uniformly in the population, greatly increasing the variance in the results. Thirdly, people who live in different places will have different exposure to the items, thus limiting the applicability of questionnaires to the population of a single country. Fourthly, such objective memory questionnaires have a short life-span and need frequent and laborious updating.

The general criticism pertaining to all three methods just described is the lack of control over original learning and subsequent rehearsal. Subjects may learn of an event, not at the time it occurred, but later from mass media, thus leading to increasing variance of exposure. To correct such bias, investigators often selected, either groups of teenagers who were too young at the time events occurred, or people living abroad for some time of their lives, to determine a baseline against which the forgetting function of the sample under study could be compared with (e.g., Squire and Slater, (1975).

Finally, there is an apparent paradox in all autobiographical and everyday memory studies. If the subjects selected are all from the same age period with an higher likelihood of equivalent exposure of events, then it is almost impossible to determine if the rate of forgetting is due to the aging of the individual or the decline of the memory trace. On the other hand, if the sample represents several age groups, then there is the danger of increasing the variance of exposure of events. Nevertheless, investigators have preferred the latter alternative due to higher internal control facilities (e.g., Warrington and Sanders, 1971; Squire

and Slater, 1975). (*)

4.3. Serial Position Effects

Next we will report and comment on some everyday memory studies that have implications for the main issues of this dissertation.

4.3.1. The recency effect and the forgetting curve

All the studies just described that reported the forgetting curve of memory episodes as a function of elapsed time have shown that recent episodes are better remembered than remote ones. This forgetting function was observed with different types of methods used to elicit episodes such as free recall, recognition, prompt-word or questionnaires. Several studies showed that recent memories are better remembered than remote ones, when subjects are asked to recall television shows and race horse names (e.g., Squire and Slater, 1975), news items (e.g., Warrington and Sanders, 1971), autobiographical memories from one's life (e.g., Crovitz and Shiffman, 1974), or autobiographical memories from a specific life-span period (Crovitz and Quina-Holland, 1976). These studies suggest that the existence of a forgetting function does not critically depend upon the type of materials

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(*) Further interpretations and comments on naturalistic memory studies can be found in Bahrick and Karis (1982), Baddeley and Wilkins (1984), and Morris (1984).

selected or the methods used.

Meanwhile a few studies have shown something new in relation to the studies reported in the previous chapters and carried out under laboratory conditions. Then it was said that recency effects were dependent on the type of test used, since recency effects had only been observed in free or serial recall, but not in recognition tests. However, when everyday memory was examined with a recognition rather than recall test it was found that recent memories are substantially better remembered than remote ones and the forgetting rate observed was similar to the classical Ebbinghaus forgetting curve.

Warrington and Sanders (1971), for example, compared free recall with a recognition test for news items and famous faces. The forgetting function for both tests was negatively accelerated (i.e., recent items were better remembered than remote ones) and did not reveal any interaction with age group. Other studies using only a recognition test have found the same negative accelerated function (e.g., Squire and Slater, 1975).

The recency effect was considered to be dependent on a retrieval process in previous chapters due to its absence from recognition tests. The underlying assumption supporting such a claim was that recognition tests circumvent complex retrieval processes (e.g., Kintsch, 1970). Thus whenever performance differences between recall and recognition are found, it is plausible to locate the factors under study at the retrieval or acquisition phase. Yet recent research has shown that not only are there retrieval difficulties in

recognition (e.g., Watkins and Tulving, 1975), but in addition recency effects may also occur in recognition tests. Recency therefore may not be totally dependent on a retrieval process. So it seems that the reason why subjects have more difficulties in remembering earlier or middle list items may be the result of either retrieval or encoding factors.

4.3.2. The rate of forgetting

Another aspect worth pointing out refers to the rate of forgetting or the shape of the forgetting curve in naturalistic studies. Almost all studies that related forgetting to elapsed time displayed the Ebbinghaus classic negatively accelerated forgetting curve, that is, forgetting increases very rapidly during the initial time periods and then declines at a lower rate. Yet Linton (1982) produced evidence showing that the forgetting function may be of a slightly different nature. Every day for six years Linton recorded the two most important events of the day and rated them along a variety of dimensions. Periodically she tested herself by selecting two events, tried to remember which came first, then to assess the date of both, and then checked her estimates against her records. The forgetting function obtained revealed not the Ebbinghaus function, but a linear function with a slope of five to six percent a year.

We may ask, of course, if Linton's forgetting function is real or not? It is real in the sense that during a short period of six years events were forgotten at the relatively

even rate of 5-6 percent each year. On the other hand it may not be real in the sense that it can not be generalized to one's life-span. If Linton's linear forgetting function was generalized, then people after 30 years should have forgotten all their early childhood memories. Why then the childhood memories or memories from the first quarter of one's life are not forgotten? Linton (1982) suggested that a different forgetting function could be observed with different or more effective retrieval cues. In addition, Neisser (1982) suggested that the reason why most of our oldest memories are still remembered may be due to repeated rehearsal and reconstruction.

4.3.3. The fate of recent events in elderly people

The third issue concerns a more detailed examination of Ribot's law concerning the degradation of memory from the recent time to the past. Old people often report that they have difficulty in remembering recent events, in contrast with their ability to remember remote episodes of their lives. Taking into account observations of this kind and some case studies, Ribot (1882) formulated his law of regression, stating that the deterioration of memory is inversely related to the recency of an event. In other words, Ribot claimed that recent memories were forgotten faster than remote ones. Although Ribot's law is based on some observational data, the experimental support for the relation between recency and forgetting was for a long time lacking.

Several studies have tried to investigate and compare the fate of recent and remote memories in subjects of different ages. Warrington and Sanders (1971) chose nine 2-year periods between 1930 and 1968 and compiled a 12-item questionnaire for each of the two year periods. The questions selected concerned striking and significant events from each period.

Subjects from four different age groups completed a recall version of this questionnaire followed by a multiple-choice version. A second test to measure memory for well-known faces was also constructed. The results revealed that memory performance declined with increasing age for all nine periods sampled. However, Warrington and Sanders (1971) found no evidence that the memories of the recent events in older subjects were more affected than in younger subjects, whether tested by recall or recognition or whether of events or faces.

Franklin and Holding (1977) examined the age and frequency of episodes elicited by the prompt-word technique in five age groups, aged approximately 30, 40, 50, 60 and 70 years respectively. When the recollected dates corresponding to each event were obtained, it was found that the median age from which subjects on average produced their recollection was 29, 35, 37, 48 and 57 years respectively for each above five age groups. In addition, Franklin and Holding (1977) found that the response latency to retrieve each episode was equivalent among the five age groups. Thus it seemed that young and elderly subjects spent an equivalent amount of time

searching the contents of their memories for the episodes prompted by the words presented to them. These results were largely confirmed in another study by McCormack (1979) with a group of subjects ranging in age from 66 to 97 years.

In summary, these studies about the fate of recent memories in elderly people have shown that Ribot's statement or "law" is not verified in the population at large.

4.3.4. Primacy and recency effects

When in an episodic memory experiment an arbitrary list of items is presented and subjects are asked to recall them with or without regard to the order of presentation, primacy and recency effects are usually obtained. There are, however, other types of information, assumed to be stored and organized in semantic memory, where the temporal and spatial circumstances of their acquisition may be less relevant. A few investigators have been interested to know if serial position effects found in episodic memory would also be obtained in semantic memory, and if so whether the explanations suggested for episodic memory could be generalized to the data obtained in semantic memory experiments.

Frequency of events

One such study was reported by Roediger and Crowder (1976). They asked university students to recall the names of

all the presidents of the United States, either in their order of occurrence (serial recall) or in any order (free recall). The results produced a classic serial position curve with best performance at the beginning and end of the series. Except for the extraordinarily high recall of Lincoln, performance of all other presidents from the middle segment of the curve was at asymptotic level.

Roediger and Crowder (1976) claimed that the results could be considered as evidence for a conventional serial position effect in semantic memory. Two criticisms can, nevertheless, be raised. One is that recall in this task is actually from episodic rather than semantic memory; another is that serial position effects are simply the result of differences in degrees of learning or differences in frequency of exposure to the name of different presidents. The names of Washington, Lincoln or Nixon are all likely to have been more frequently encountered in books, films and the news media producing more extensive learning than for any other president.

It is of course impossible to counterbalance items against serial position when one is studying serial position effects in semantic memory. Yet it seems unlikely for example that the name J. Adams (2nd president) occurs more frequently than T. Jefferson (3rd president), and yet the former was better recalled. And the same could be said presumably about Roosevelt (7th) and Eisenhower (5th) at the recency portion of the function. Unfortunately the authors did not provide any statistical analysis to prove the negative linear trend in

primacy and the positive linear trend in recency. Roediger and Crowder (1976) argued that their results could be sufficiently explained if a common mechanism applicable to both episodic and semantic memory and based on the distinctiveness of positional cues was postulated.

Another serial position function in autobiographical memory was obtained by Riegel (1974). In this experiment undergraduate students were asked to write down as many names of persons they had met during their lifetime (e.g., relatives, friends, acquaintances) as they could recall during a six minute period. When data were plotted as a function of the subject's school age periods, strong primacy and recency effects were obtained respectively at preschool (1-6) and at university (19-21) periods. Again in this study the primacy and recency segments were not analysed statistically.

McCormack (1979) used the prompt-word technique with elderly subjects aged on average 80 years, to determine the frequency of occurrence and latency of remembered episodes. When the results of three experiments were plotted as a function of quarters of the life-span a serial position function was obtained for the frequency of remembered episodes. The frequency of memories elicited was highest in the first quarter of life, then declined steadily to the third quarter, and then recovered again for the most recent quarter. The results were equivalent for male and female subjects and were stable across the three experiments.

In contrast McCormack (1979) did not obtain any difference in response latencies for each quarter of

life-span. Such a pattern of results may suggest that subjects did not use different strategies to retrieve memories from each quarter of life-span and that the episodes remembered had equivalent salience in the subject's lives.

In another study Whitten and Leonard (1981) investigated the effects of search order through autobiographical memory. It was mentioned in previous chapters that recall of a well ordered set of items is dependent on the experimenter's instructions to start recall from the beginning, end or the middle of the set of to-be-remembered items. Usually recall performance in immediate free recall is better when subjects are asked to recall first the items from the end of the list.

Whitten and Leonard (1981) asked university students to recall their preuniversity teacher's names in forward (1-12), backward (12-1) or random order. The backward ordered search proved to be the most efficient with fewer students failing to complete the task in this search order. In addition, those students who completed the task in the backward order were faster than the successful students in the two other search orders. Therefore these results revealed that recall of one item from a well ordered set of autobiographical memory can indirectly help the recall of contiguous items, especially if the search is primarily a function of recency.

A related finding with theoretical importance in Whitten and Leonard's study was the absence of a primacy effect on recall performance of teacher's names. Several

experiments, reported in previous chapters that were carried out in the laboratory produced the bow-shaped function. Teacher's names constitute a semantic category with well defined end-points, as in the laboratory experiments yielding primacy effects, but the primacy of teacher's names was not sufficient for their superior access in memory. Whitten and Leonard (1981) argued that a prerequisite for the occurrence of primacy effects may be the encoding of a sequence of information as an interrelated set. In other words, it is unlikely that teacher's names from the first and subsequent years were encoded as an organized, interrelated set of inputs to memory in the same way as to-be-remembered items from an episodic memory experiment carried out in the laboratory.

The major problem with Whitten and Leonard's argument is their failure to specify the characteristics of an interrelated set of to-be-remembered items. Even if the presence of a interrelated set was a necessary condition to obtain serial position effects in semantic memory what is lacking in teachers's names that is present in Riegel's (1973) experiment about the friends his subjects met, and Roediger and Crowder's (1976) experiment about the names of the United States presidents? It is acceptable to claim that the contents of the memories from all these experiments were represented in semantic memory. However, it is hard to understand why some of these contents are interrelated and others not.

Latency of responses

Serial position functions have also been obtained with response latencies, although the outcome is not always consistent across all experiments to be reported. The best well known experiment of this kind was carried out by Koriat and Fischhoff (1974). These investigators stopped 273 passers-by on the campus of the Hebrew university in Jerusalem and asked two questions, timing the response to each: what is the name of a country beginning with the letter "G"? What day is today? Times in seconds for the production of a correct response for the day of the week from Sunday through Friday were respectively 1.2, 1.5, 1.8, 1.9, 1.5, and 0.9. These data revealed a clear curvilinear relationship with the ordinal positions of the day of the week with the longest latencies on the midweek target days.

Koriat and Fischhoff (1974) proposed two alternative models to account for the observed serial position effect. One model would postulate that days of the week are retrieved in order and matched against available evidence. To produce the bow-shaped function it requires a further assumption that sometimes the scan procedure begins with the early part of the week and sometimes with the late part of the week. Another model would postulate temporal landmarks (e.g., weekends) along a spatial or abstract dimension which, due to their high distinctiveness, serve as an anchor mechanism to attract the search process.

Robinson (1976) selected three classes of prompt-words

designating object words (nouns), activities (verbs) and affect words (adjectives), as guides for elicitating discrete experiences from university students. Among other findings, Robinson observed that the time required to retrieve an episode (latencies) displayed a curvilinear function when plotted as a function of three 5-year life-span periods. The median latencies obtained were highest for episodes recalled from five to 10 years and almost identical for the most recent (11 - 15) and the earlier interval from zero to five years. Robinson (1976) pointed out that similar latency results were obtained for the subgroups of male and female students when their response times were analysed separately.

In contrast to Robinson's results, McCormack (1979) did not find any difference in latencies for his elderly subjects as a function of quarters of life-span. Results on response latencies were obtained by Franklin and Holding (1977) who selected five different age groups of 30, 40, 50, 60, and 70 years old and asked their subjects to recall episodes from their lives. The prompt-word technique was used. Between group results revealed that younger or older subjects retrieve their past memories at a similar rate. However, Franklin and Holding (1977) did not analyse their data according to life-span periods within each group, therefore their results may not contradict Robinson's within group results. Thus a curvilinear latency function was obtained with young university students within the first quarter of their life-span in Robinson's data, but not in elderly subjects between the four quarters of their life-span

in McCormack's experiments. It seems that further data are necessary to clarify this issue.

4.3.5. Summary

The data reported so far have shown that recency is a robust phenomenon obtained both in the laboratory and in naturalistic memory studies. Although the data is not totally clear, it seems that recent episodes are retrieved faster than older episodes within each age group.

On the other hand, primacy effects have been largely absent in everyday memory studies. It seems that the emergence of primacy effects requires a defined starting point, and many of previous studies did not have a conventional beginning (e.g., famous personalities faces, striking news items, television shows, race-horse names and so on). However, in some cases, it seemed that a conventional starting point was present (e.g., teacher's names) and in fact primacy was absent. It may be that memory for teacher's names, USA president names, and the names of relatives, friends and acquaintances are not organized in memory in the same way. However, I suspect that the data reported are insufficient to draw any reasonable conclusions about primacy effects in everyday memory.

4.4. Recency Judgements and Temporal Order

The normal adult encompass an enormous nunber of

memories, some of them reflecting experiences that occurred at definite points in time. Graduation day, the beginning of a special friendship, a wedding, the first job, a son's birth, moving to a new howse, retirement, as well as external events from politics to catastrophes might be the most salient events in the chronicle of one's life.

An account of one's life implies an ordering of events that corresponds with the true ordering. Sometimes the temporal ordering is not a difficult task to perform, because there is a necessary order in the events. The wedding usually follows the establishment of a special friendship and precedes a son's birth. However, these salient events are a mere drop in the ocean of one's life. When many other events are remembered, some of them incorporating very detailed contexts and circumstances, it is often the case that subjects feel embarrassed about their inability to date or order them.

Determining the temporal order of two events or a series of events is very often independent of their degree of importance, salience, emotionality, to their occurrence being personal or shared with other people. A flashbulb memory, for example, about my grandmother's death paired with the small salience of my first visit to the dentist does not help me very much to determine which of two events occurred most recently.

4.4.1. Temporal order discrimination studies

Research on temporal order and recency judgements has

focused on the discrimination of temporal order as a function of the age of the events and the interval between them, and on strategies used to achieve this discrimination.

A few studies have been reported on memory for the temporal order of everyday events. Underwood (1977) selected 24 brief statements describing social, political and sport events that hit newspaper headlines in USA from 1968 to 1975. The events were divided into three lists of eight each and only one list was given to each subject in the autumn of 1975. The subject's task was to estimate the month and the year for each of the events. The results revealed that the subject's mean judged date in months for each 24 events tested fell very close to the diagonal line indicating the true number of months, that separated the real occurrence of the events from the testing occasion.

The product-moment correlation between judged number of months and the retention interval was 0.96 for the 24 events. Results were further analysed to observe the number of errors in ordering two events as a function of their separation in time. It was expected from several previous studies that the close two events have occurred in time the more difficult it would be to estimate their temporal order. The expectation was confirmed. The greater the amount of time separating two events the smaller the number of misordering those events.

In another study on memory for unique personal events, Thompson (1982) asked 16 class members to record unique personal events for themselves and their roommates for about a

semester. Each week, each subject attempted to record two events each day from Monday to Thursday for two individuals, the class member and another individual who shared accommodation with the class member. It was emphasized that the events should be unique, not embarrassing and described in three written lines or less. The recorded items were rated for their future recallability and were collected at the end of each week. At the end of the semester roommates were informed about the study and asked if they were prepared to be tested one week later.

At the testing session, subjects dated the events as accurately as possible, only in the case that prior positive answers were given about the uniqueness of the event and the likelihood of the event to be recalled. The results revealed that the number of errors in judging the correct date of the event increased as a function of the retention interval, but accuracy of dating an event fell close to the diagonal line relating the retention interval to the judged date. The data did not reveal any reliable effect for the type of subject (e.g., recorder versus roommate) or any interaction with retention interval. This result was surprising. In spite of the fact that recorders selected the events, recorded the events and knew they were going to be tested for the memory of the event, their dating accuracy was not reliably better than that of their roommates.

One of the limitations of an everyday study of this kind is the difficulty of selecting groups of two equivalently salient events with always the same temporal lag between them,

but with different ages. Events separated by a 6-month interval may be easier to order if the age of the most recent pair is one year rather than five or ten years. It is not very demanding and it does not require a lot of imagination to set up an experiment in the laboratory to test this hypothesis. On the other hand, finding appropriate everyday episodes to test the hypothesis is almost always a very ingenious enterprise.

Fortunately, Squire, Chace, and Slater (1975) have come up with such a study. Squire et al. selected 80-one season television programs that had been aired for only one season between 1957 to 1973. A 3-alternative multiple-choice test of 36 questions was constructed, which repeated the question: "Which of the 3 television programs was on the air most recently?" The correct answer was always the name of a program that had been aired for only one season between 1962 and 1973. The two incorrect answers were the names of programs, that had been broadcast five years prior to the correct choice (e.g., 1957 to 1968). Thus the temporal lag between the three choices was kept constant at five years and the variable manipulated in the study was the age of the programs.

Squire et. al. (1975) pointed out that the exposure of the programs aired during the 16 years was broadly equivalent. Program ratings were similar and the number of households having television sets increased only from 95 to 97% during that period.

The shape of the results obtained was similar to

previous laboratory findings: the number of errors increased as a function of the age of the programs. In addition, the results indicated that subjects were able to judge the temporal order of past television programs rather better when the elapsed time was less than five years for the correct choice than when it was longer.

4.4.2. A provisional model for temporal order

A minimal model for temporal order and recency judgements would assume that events are tagged at the time they occurred in association with other events. Events are tagged not in the sense that a date is attached to them, but in the sense that the order of the event could be inferred subsequently by comparison with other minor or major events that preceded or followed the target event. It is assumed in this case that every event can be correctly ordered in the days and perhaps weeks immediately after its occurrence. Sometimes a specific date is associated with the event. In such cases, the simplest way is to locate the event, search and read off the information. Events of this type are for example the French student demonstrations at the end of the 1960s, which became known as "May 68".

When the event can not be dated directly, then a usual strategy is a search for temporally overlapping events, which can be more easily dated. If the first overlapping event provides a date, then the problem may be solved. For example it could be a difficult task to date Nixon's resignation as

president of the United States. However, when I tried to find out some overlapping event, I remembered that I read the news while I was in France on a holiday. In addition, I remember that up to now I have only taken holidays abroad in August. Thus Nixon's resignation must have occurred in August. A check confirmed that this was true.

When the first overlapping event does not suggest any date, there are several alternative strategies, and subjects reports differ. Typically the target event is further analysed in the hope of retrieving additional cues or new overlapping events, thus providing further information about the date. Sometimes little temporal information is retrieved. It is possible for example that subjects can remember the day of the week (Wednesday or Sunday) but are quite unable to remember the month or the year.

I personally remember that Robert Kennedy was shot early on a Wednesday morning GMT, because I was on a weekly excursion from college, and such excursions always occurred on Wednesdays. I further know that I read the news in a new edition issued in the afternoon of a local morning newspaper. However, I was unable to remember accurately the month or the year. The only thing I was sure of was that the month fell during the academic year and if I was pressed to guess I would choose a spring rather than an autumn or winter month, since the day was sunny and I presume hot as well. Guessing again the year fell between 1967 and 1970.

When the date of Kennedy's assassination was checked (5/6/1968) and I started to look in the newspaper for news

that occurred earlier or after Kennedy's assassination, other salient remembered events were temporally ordered: Luther King's assassination (April 1968); the French student demonstrations (May 1968); the illness of the Portuguese prime minister Salazar (July 1968) and his replacememt by Marcelo Caetano next September; and the invasion of Czechoslovakia by the Warsaw pact forces in August 1968. In addition, I remembered that my fifth year examination in the secondary school occurred at the end of June, 1968. Such an event is quite well remembered by almost all students of my and previous generations.

The amazing thing, as well as the embarrassment caused by these memories, was not so much that I was able to remember all these events quite well and some with great detail, but my failure to establish their temporal order if I was tested. Even though the events were still memorable after 15 years, memory for the temporal order of their occurrence had deteriorated. In fact it was quite possible that all these events (apart from the replacement of the Portuguese prime minister where one event follows necessary the other), had never been encoded in my memory as an ordered interrelated set. Although it may have been possible to establish the temporal order of those events on 31st December 1968, the overlapping events generated at the end of that year to assess the temporal order may have been minor incidents that I largely forgot in the following years.

The strategies used to determine the relative time of occurrence of two or more events depends also on their mutual

relationship. Popes, kings, presidents and prime ministers are replaced by other candidates and usually there is a necessary order in such a sequence. When the temporal order for example between the deaths of a political figure and of a major figure in arts, cinema or painting can not be retrieved, the cause could well be the absence of any interrelationship established and encoded between the events at the time of their occurrence. Even though some of our past memories could be categorized under the heading "famous peoples names" the specific events in such file may be no more interrelated than are foods such as cod, potatoes, sugar and wine presented in different lists and tested some hours or days later for recency and temporal order judgements.

4.5. Overview

How do people establish the temporal order of past events and group them in memory? Are the contents of events organized according to separate chunks or interrelated sets (e.g., school life, professional life, family life, entertainmemt life, major news items and so on) or is there a continuous temporal organization? If individual differences in temporal order judgement were obtained, would they be more dependent on lifestyle, personality or both? We still do not know the answer to these questions. We have some good memory models and a few of them seem very sophisticated and of some generality. Yet we do not have a good representative model for autobiographical and naturalistic memory.

Chapter 5: DISCUSSION AND INTRODUCTION TO EXPERIMENTS

5.1. Interpretations of Serial Position Effects
5.1.1. The recency effect
5.1.2. The primacy effect
5.2. A Common Interpretation for Serial Position effects
5.2.1. The end-points scan hypothesis
5.2.2. The temporal discontinuity hypothesis
5.3. Overview
5.4. Introduction to Experiments

SUMMARY

In Chapter five three questions are addressed: Firstly, is recency in STM and LTM tasks dependent upon the same cognitive process? Secondly, are primacy and recency the result of similar or different processes? Thirdly, is there a common interpretation for serial position effects? The data are discussed according to the view that for the time being a common interpretation is better suited to account for all data available than particular explanations.

Finally a brief introduction to the experimental work of this dissertation is given.

5.1. Interpretations of Serial Position Effects

Recency and sometimes primacy effects have been described and several interpretations suggested, when the standard free recall task, the continuous distractor paradigm, as well as recency and lag judgments were examined. At this stage the experiments reported may be enough to draw a preliminary conclusion based on the answers to the following questions that have been alluded to in previous Chapters:

(1) Is the recency effect in short and long-term memory tasks dependent upon the same or different memory processes?

(2) Is recency caused by the same mechanisms as primacy or must different explanations be considered for each of them?

(3) Is there a common interpretation for serial position effects?

5.1.1. The recency effect

When STM tasks were analysed in the first Chapter, it was argued that recency effects could be better explained by a retrieval interpretation than by alternative ones. A retrieval hypothesis was also supported by data reported on Chapter two on LTM tasks. Therefore, I should like to argue that recency largely reflects a retrieval process, that can be applied to short- and long-term memory stores (e.g., Baddeley and Hitch, 1974; Bjork and Whitten, 1974). Arguing that

recency is a retrieval process means that subjects tend to start recall from the end of a sequence of items of a known-length list, rather than from any other segment of the list. Subjects' strategies may be based on the assumption that terminal items will be more difficult to retrieve at the end of a recall period than earlier in the test. In addition, this retrieval strategy may be established in the course of the first few trials and maintained thereafter.

The major evidence that recency is a retrieval strategy is based upon three different sets of findings: (1) Recency effects are typically not found with recognition testing in laboratory tasks; (2) Recency in STM tasks is affected by output order; (3) Recency is enhanced with practice.

These findings were obtained in STM tasks and partially confirmed in the continuous distractor paradigm, a long-term memory task. I suspect that the absence of output order effects in the continuous distractor paradigm, reported by Whitten (1978), require further research, since output order was observed in short-term memory tasks, as well as in naturalistic memory studies (Whitten and Leonard, 1981). In addition and as far as I know, research on practice effects in the serial position function with long-term memory tasks has not yet been reported.

One of the best models to account for recency effects is the positional discriminability hypothesis proposed by Bjork and Whitten (1974). According to them, recency is the

result of a retrieval process based upon the discriminability of items from each other. In a metaphor suggested by Crowder (1976, op. cit. p. 462), subjects at the retrieval stage look back towards their past memories just as when we are moving in a train we may look back at telephone poles that have passed by. The assumption is that just as each telephone pole is harder to discriminate from its neighbour the farther they are from the observation point, likewise each item in a memory list becomes less distinctive from the other list-item as the lag between their presentation and test increases.

Bjork and Whitten (1974) proposed that the discriminability of equally spaced events as a function of the passage of time follows Weber's law. This implies that the just noticeable difference between adjacent memories is a constant fraction of the most recent of the two memories considered. Assuming, for example, that subjects are just able to discriminate between two items presented one and three seconds earlier, then it would be possible to discriminate between two other items provided that the ratio between them is 1/3. Therefore, in a sequence of items, an item presented 10 or 90 sec earlier would only be discriminated from another item respectively presented 30 or 270 sec earlier.

Although the discriminability ratio accounts not only for the recency effect, as well as for recency judgments, and can predict easily the minimum lag of two items in order to be recalled (e.g., Lockhart, 1969), the model can not explain why primacy items that should be melted and undistinguishable in the mists of the receding past are recalled better than many

other middle list items. This criticism could be overcome and the positional discriminability hypothesis saved, if it is assumed that the perspective from which the past is scanned could be located either at the end or at beginning of a sequence of items. If this were so, then primacy effects would be the result of a few items being scanned from the beginning of the series.

If recency is the result of a ratio rule (Glenberg et al., 1983) or the result of Weber's law (Bjork and Whitten, 1974), what is the mechanism for item discrimination that supports such models? It was suggested in Chapter two that the retrieval process was based upon contextual or temporal order cues, and Chapter three was an attempt to investigate this hypothesis with recency judgement tasks. However, attempts made to support a contextual cue mechanism have been neither successful (Underwood 1977) nor exempt from criticism (Glenberg et al., 1983). In contrast, little is known about the effects of temporal order cues on recency. Therefore, an attempt was made in this dissertation to investigate the effects of order cues in experiments two, three and four.

In summary, it seems that a retrieval process can satisfactorily account for the recency effect obtained in the standard free recall task, the continuous distractor paradigm and presumably in all tasks involving a free recall procedure. There are however other tasks where recency effects have been obtained, such as probe recognition tasks (Waugh and Norman, 1965), Serial recall tasks (Schultz, 1955; Ebenholtz, 1972), list recency tasks (Tulving and Psotka, 1971; Bjork and

Whitten, 1974) and with the savings testing method (Ebbinghaus, 1885/1964). Whether or not recency effects obtained in these tasks depend upon the same mechanism as in free recall tasks, it is another issue that it will not be discussed here.

5.1.2. The primacy effect

It was reported in previous Chapters that primacy and recency effects were interpreted by several investigators as different processes: while primacy was largely dependent upon a storage process due to active strategies, such as rehearsal, recency is probably based upon a retrieval process.

The evidence previously reported was that while recency was reduced or dissipated in a recognition test, final total recall test, or in cued recall test, very often a primacy effect was observed in those test procedures (e.g., Craik, 1970; Darley and Murdock, 1971; Baddeley and Hitch, 1974; Watkins and Watkins, 1974; Maskarinek and Brown, 1974; Dalezman, 1976; Poltrock and Macleod (1977). Therefore, the emergence of primacy effects under several testing procedures, mainly in a final total recall test, would indicate that it is likely that primacy is a storage rather than a retrieval mechanism and it is dependent on rehearsal and other extra activities of input processing. When extra processing is eliminated, either by a difficult interitem task, concurrent storage load, or in an incidental recall test, primacy effects are largely reduced if not sometimes eliminated (e.g.,

Baddeley and Hitch, 1974, 1977; Glenberg et al. 1980, 1983). Therefore, it is plausible to argue that the primacy effect is based upon storage rather than retrieval processes.

However, primacy is not totally dependent on extra processing of initial items. It has also been observed that the primacy effect depends upon the effects of practice and changes in output order after presentation of several experimental lists. Recall of first experimental lists usually show higher primacy effects than later lists (e.g., Maskarinec and Brown, 1974; Dalezman, 1976; Goodwin, 1976). Dalezman (1976) found that the primacy effect in a final total recall test varied as a function of the output strategy. When subjects were cued to start recall from the beginning of each list presented in the session, primacy effects were enhanced relative to the instruction to start from the end of each list. There are also results from an incidental task, where primacy effects were obtained (e.g., Baddeley, 1977, Fig. 4. p. 653).

What these studies seem to show, however, is that recency is much more sensitive to changes in output order than primacy. On the other hand, primacy effects may be more dependent on active processes at the encoding and storage phase than recency, specially in the standard free recall tasks, but, like recency effects, primacy reflects undoubtedly a retrieval mechanism.

After all, subjects know better when the first few items are being presented than the last ones in a sequence of to-be-remembered items. If the positional knowledge about

items from both ends-of-a-list was equivalent, subjects would probably engage in the same encoding processes in order to retrieve primacy and recency items later.

5.2. A Common Interpretation for Serial Position Effects

While some investigators are keen to discover and expose differences among phenomena, others prefer to stress the similarities observed. In science, progress has been made following both approaches. It was suggested earlier that, despite the evidence to support a different process account of primacy and recency, both effects could also be dependent on a retrieval process. Like many other memory phenomena, primacy and recency can be a joint manifestation of what has ben encoded, and how what has been encoded is being retrieved (Tulving and Thompson, 1973).

A few attempts have been made in the past to put forward a common interpretation for serial position effects. It seems to me that such interpretation is in great need, since serial position effects have been obtained in the recent past with preverbal infants (Cornell and Bergstrom (1983) and infrahuman subjects (Buchanan, Gill, and Braggio, 1981; Sands and Wright, 1980) where it is out of question to argue that subjects have engaged in some sort of rehearsal activity. In addition and contrary to several developmental studies that have shown differences in primacy as a function of scholar

grades, Huttenlocher and Burke (1976) revealed that primacy was just as pronounced in the first grades as in the third and fifth ones. These results seem to suggest that primacy and recency effects are originally an automatic process. By saying that, it does not exclude the contribution of other cognitive processes such as rehearsal that add to the original strength of the serial position effects.

5.2.1. The end-points scan hypothesis

The end-points scan hypothesis was a first attempt to produce a common interpretation for serial position effects. The hypothesis assumes that since the ends of a list are distinctive and discriminable, then such a search will yield higher recall for end than for middle list items.

Meanwhile, one may ask why do terminal items attract the search process? Is it because their traces are stronger or are terminal items encoded differently from previous items? It is a circular argument to claim that terminal items are better recalled, because they are more discriminable. To be fair, that may be partially the case in some memory tasks, although there are strong arguments against the trace strength hypothesis, which were described in some detail in previous Chapters.

Meanwhile, investigators have tried to overcome such criticisms by assuming that ends-of-a-list are cued as such, and that that cue is for some undefinable period powerful enough to attract the search process. For this reason, it

follows that what the middle list items lack is a distinctive cue attached to them to act as an anchor for the search process. When such a cue is present (e.g., a digit in the middle of a letter sequence) higher levels of recall are obtained, an effect that has been known as the Von Restorff effect.

The end-points scan hypothesis is closely related to theoretical approaches put forward by several investigators (e.g., Whitten, 1978; Dalezman, 1976; Ebenholtz, 1972; Murdock, 1960; Shiffrin, 1970) and summarizes their views.

5.2.2. The temporal discontinuity hypothesis

A related theoretical hypothesis, that I want to put forward, will be referred as the temporal discontinuity hypothesis. This hypothesis claims that series of items presented in the laboratory change the ongoing subjects activity, specially when the items start to be presented and when they end up. These changes are regarded as temporal discontinuities in subjects' actions, thoughts and expectations relative to an hypothetical stable and relatively unchanged present.

It is well known that the visual system is particularly sensitive to the edges of a luminance field (see studies by Hubel and Wiesel quoted by Lindsay and Norman, 1977, Chapter 2). Likewise I would like to claim that the cognitive system, for evolutionary reasons or others, is also particularly sensitive to the temporal discontinuities of a

task with the maximum discontinuity level located at the end-points. Since the temporal discontinuities of a task are associated with greater changes in the ongoing subject's activity, the contextual cues originated from both the temporal discontinuity of the task and the correspondent changes in subject's actions, thoughts and expectations become associated with the ends-of-the-list. Therefore, the distinctiveness of the terminal items resulting from an enriched context acts as an anchor for the retrieval process and primes the near by items.

The two hypotheses discussed above have the advantage, firstly, to explain recency as a retrieval process applied to any memory store; secondly, both hypotheses can account for primacy, recency and Von Restorff effects as the result of an automatic cognitive process; thirdly, both interpretations are general enough to fit almost all data available. In addition, the temporal discontinuity hypothesis has the advantage of making predictions and accounting for empirical data that has been left unexplained or where an alternative explanation was otherwise necessary.

One such set of data is an intriguing result observed by Baddeley and Hitch (1977). In an incidental free recall task, Baddeley and Hitch (1977) gave subjects a sequence of 12 names to classify as male and female. Although subjects were not previously informed that they will be required to recall the names later, they were asked to recall them either

immediately, or after a 30-second delay interval. The interval was either filled or left empty, while the experimenter shuffled papers as if looking for the next experiment. The results indicated that percent recall for the most recent item was equivalent in both the immediate recall and the 30-seconds unfilled interval. In contrast, the filled retention interval suppressed the recency effect.

The fact that recency was obtained after 30 seconds unfilled retention interval, but not after an equivalent filled one, means that in the former case the end of the name classification task was clearly located when the classification of the 12th name took place and the blank retention interval constituted a clear discontinuity to the previous task. In contrast, in the filled retention interval, the end point of the 12th name classification was masked by the beginning of the arithmetic task, and subjects had increasing difficulty in directing the search process to the end of the verbal sequence. But are not in principle the two tasks different enough to indicate a temporal discontinuity between them? After all, one is a classification task of human names, and the other is coping digits for 30 seconds.

The answer is that the difference may not be radical enough. Watkins and Peynircioglu (1983) confessed that in an unpublished study they have failed to enhance the recency effect by rotating the taxonomic categories from which the successive words were drawn (e.g., animals, professions, and chemical elements) or by alternating between male and female-voiced presentations. However, when Watkins and

Peynircioglu (1983) selected categories with more radical discontinuities among them (e.g., riddles, sounds, drawings, objects, favorites and quiz questions) and when they interwove a list of 15 items of a given category (e.g., riddles) with 15 items of each of two other categories (e.g., sounds and drawings) separate recency effects were obtained for each of the three categories within the one list of 45 items.

The temporal discontinuity hypothesis also predicts a difference in recall of the terminal item from each category at position 43, 44, and 45, when each of these serial position points are cued first for recall. Since the major temporal and contextual discontinuity in this experimental task only follows the item 45 (i.e., the end of item presentation and the beginning of the cued recall task) then, when item 45 is cued first for recall it will be better recalled than when item 44 or 43 (i.e., the terminal items of the other two categories) are firstly cued for recall. This was in fact observed (see Watkins and Peynircioglu, 1983, Fig. 5, p. 383).

5.3. Overview

In summary, my personal view is that primacy, recency, as well as Von Restorff effects can be accounted for by the same mechanism. This mechanism seems to be automatic in nature and supports a basic human need to keep track of past events and to maintain orientation in time and space, as Baddeley and Hitch have earlier suggested (e.g., Baddeley,

1983; Baddeley and Hitch, 1977).

However, Baddeley and Hitch only regarded this mechanism to account for the recency effect. It seems to me that such mechanism loses part of its appeal, if it is not extended to the primacy effect. And an example from everyday life may help to understand why. If, for example, a person without previous experience of flying was going to fly for the first time and asked for advice, it would be much more helpful if I was able to remember the fears and pleasures of my first flight than the last one. Countless other examples of parents' advice to children could be given. Therefore, if recency, for evolutionary reasons or others, is an important mechanism to keep track of past events, primacy is no less important either. In addition, data from infrahuman subjects, preverbal infants and developmental studies may be better understood.

Finally, it may be argued that a common interpretation for serial position effects is theoretical uninteresting, since it discourages research attempts to find out the mechanisms responsible for each effect. My answer is that at this stage, a common interpretation seems to be the largest common denominator to account for data available, but this may not be so in the future.

5.4. Introduction to Experiments

The seven experiments to be reported next were not

carried out to check the validity of the hypotheses discussed in this Chapter. Firstly, such hypotheses are very general, making it difficult to test them easily; Secondly, when I started carrying out the experimental work for this dissertation three years ago, I did not have a clear defined model for primacy, recency and temporal order as I developed later in my studies. Thus, the experiments that I carried out were designed to test more specific topics concerning the theme of this thesis.

In the first experiment, I attempted to explore if primacy and recency effects obtained in the standard free recall and the continuous distractor paradigm were age dependent or not. In addition, I tried to examine if the tasks and the two age groups selected interacted in any way at the recency portion of the serial position function.

The next three experiments (2,3,4) examined the effects of temporal order cues in a list recency task. The purpose of this set of experiments was to examine whether or not the recency effect was affected by the presence or absence of a strong semantic cue.

The last three experiments analysed recency effects in a naturalistic setting. The first experiment explored the presence of recency effects in memory for car parking and investigated how elapsed time and the number of interpolated events affected the recency effect. The final two experiments examined these two variables again, but with a different experimental design.

CHAPTER 6: The Locus of Age Deficits in the Serial Position Function

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SUMMARY

This experiment investigates ageing differences in the three main portions of the serial position function (SPF) in the free recall task (FR) and the continuous distractor paradigm (CD). The purpose was threefold: Firstly, to explore age differences in the three main portions of the SPF in both tasks; Secondly, to examine and possibly resolve the controversy about age differences in primary memory and in the recency portion of the SPF; Thirdly, to discover any relationship or strategy in subjects' performance in the three recency conditions.

Among other findings the data showed: (1) The CD task is more sensitive to age differences than the FR task; (2) Primary and secondary memory stores were smaller in elderly, and an interaction between age and memory stores was observed; (3) The data were not conclusive on the question of age and recency although an interaction between tasks and recall at the recency segment was obtained. The data were discussed in relation to several hypothesis and the contextual retrieval hypothesis was favoured.

INTRODUCTION

In the recent past many publications have investigated cognitive processes in ageing and it seems a proper question to ask why this interest has grown so fast? One of the primary interests of psychological research in general and ageing in particular is to determine the practical importance of its discoveries for modern society. Future social policy decisions may differ depending on whether it is concluded that getting old is marked by deterioration of nearly all job relevant abilities or if only sensory and physical skills are found to decline.

At the time this chapter is being written, a controversy has emerged in the American newspapers about whether, in view of his age, president Reagan is fit to rule the country in his seventies. There is no doubt that, in these or other circumstances, a good understanding of the cognitive abilities of elderly people is very helpful for policy makers, or voters.

A reading of the literature on age differences discloses two broad approaches to age decrements found in old age. On one hand, there are those investigators who accumulate evidence showing the inevitable and progressive loss of cognitive efficiency in old age (e.g., Salthouse, 1980; Burke and Light, 1981). On the other, there are those who believe that any cognitive decrements observed in elderly people appear to reflect inefficiencies of processing rather

than reflections of broken or lost components (e.g., Craik and Rabinowitz, 1984; Craik, 1977). While the former approach is particularly accused of being "theoretically uninteresting", because it offers little opportunity for remedial intervention, others argued that there is no advantage to elderly people in concealing the truth about their cognitive impairment, Kausler (1982).

There has been in the past a few major trends in ageing research. One of the most influential approaches has derived memory research hypotheses from current theory and accounted for ageing differences either in terms of memory stores (i.e., sensory store, short-term store and long-term store), control processes (e.g., verbal rehearsal, clustering, categorization, imagery, etc.), or stage analysis (encoding, storage or retrieval).

Thus far evidence has been gathered showing that age decrements are larger and more reliable in long-term or secondary memory, than in short-term or primary memory (e.g., Craik, 1968), that the elderly utilize imagery less often and effectively than younger adults (e.g., Treat and Reese, 1976); that they exhibit less organization of to-be-remembered items (e.g., Hultsch, 1974); that they rehearse items at slower rates (e.g., Salthouse, 1980); and that age differences are reduced where retrieval requirements are minimized, such as in recognition tests or cued recall tests (e.g., Smith, 1977).

The evidence with respect to localizing the age deficit at encoding or retrieval is very confusing and such an

approach has been discouraged recently by Craik (1977). Craik argued that "there is no point in prolonging the debate on whether age differences are due to acquisition or retrieval. Undoubtedly some situations can be found in which acquisition is the major problem ... while in others, retrieval will be the major source of difficulty. The next phase of research in this area must attempt to elucidate the interactions between experimental situations and the postulated memory processes" (Craik, 1977, op. cit. p. 408). Moreover, even if a stage analysis approach was successful in isolating the age difference in a single stage, it might still not be enough, since the mechanism responsible for the decline could be a more general and fundamental one.

A second approach in ageing research, and perhaps the most popular current approach to memory decline in old age, is derived from the levels-of-processing framework (Craik and Lockhart, 1972). In this view incoming information can be encoded at a shallow (i.e., physical appearance) or at deep processing level (i.e., in terms of meaning). Deeper or more semantic analysis produces a richer or more elaborated memory trace, which is more resistant to forgetting (Craik and Tulving, 1975). According to this approach, older subjects may not spontaneously encode items semantically, or are less likely to access the meaning of new inputs. There are two versions of the levels-of-processing hypothesis that account for a lower efficiency in encoding the meaning in elderly people.

The first version claims that elderly do not apply deep processing strategies spontaneously, but only when they are forced to do so. In this case no significant differences are expected when deep processing is ensured in both groups (e.g., Craik and Simon, 1980; Craik and Rabinowitz, 1984). This is the production deficiency hypothesis.

The second version assumes that elderly are unable to perform deep semantic processing operations as efficiently as young people. When putting forward the processing deficiency hypothesis, Eysenck (1974) suggested that shallower processing ability remained intact, but deeper semantic processing was impaired by age. In a recent and substantial review of the literature, Burke and Light (1981) argued that the production deficiency hypothesis is unable to account fully for the poorer performance on several memory tasks by older adults. Therefore they argued that the processing hypothesis must be regarded as a valid theoretical account.

Another direction in memory research is to generate research hypotheses from memory paradigms and memory data. This was suggested as an heuristic approach by Salthouse (1980) in a chapter of the book "New Directions in Memory and Aging". Salthouse claimed that a fruitful approach, as a source for new hypothesis, is to select a well investigated memory task or phenomenon (e.g., the serial position curve) and to let the age deficits emerge from the data. Since such paradigms usually involve different effects with different mechanisms to account for each of them, an examination of such

mechanisms or factors may provide an effective new hypothesis, whenever age differences are obtained. Since my research project was concerned with the analysis of serial position effects, it seemed natural to extend such research to the issue of memory and age differences in elderly.

To start with, two well known memory tasks were selected: the free recall task (FR) and the continuous distractor paradigm (CD), first used by Bjork and Whitten (1974) and Tzeng (1973). These tasks have been regarded in the literature as tapping different memory processes, and perhaps stores, and an extensive review was given of each of them in Chapters one and two.

The major differences between FR and CD tasks may be attributed to the mechanisms responsible for the recency segment of the serial position function, and the amount of processing resources needed to execute each of them.

While the recency effect in the FR task has been accounted for by the existence of a temporary buffer store of limited capacity (among other interpretations), in the CD task a new mechanism has to be assumed, since recency survives the presence of an interpolated activity separating each of the to-be-remembered items.

Previous experiments on age differences have reported conflicting evidence about the impairment in elderly subjects over the recency portion of the serial position function or the primary memory (PM) store.

Several investigators have claimed that the locus of

the age differences in memory is limited to the secondary memory (SM) store. Craik (1968) and Raymond (1971) showed that the age factor did not affect the size of the PM store capacity and Wright (1982) using one of the several methods available for calculating the PM component, replicated the previous evidence.

On the other hand, Arenberg (1976), Salthouse (1980), Parkinson, Lindholm and Inman (1982), and Wright (1982) did show the average proportion of words recalled in the last three terminal positions to be smaller for elderly than for young subjects.

This apparent contradiction between presence and absence of age deficits in PM capacity may be overcome if it is assumed that recency effects reflect the operation of both primary and secondary memory (Waugh and Norman, 1965). However, this suggestion proposed by Wright (1982) to account for such contradictory data is misleading, since the methods employed for obtaining either PM capacity or the recency size produce identical (Tulving and Patterson, 1968), or very similar estimates (Tulving and Colotla, 1970) of PM and recency parameters.

Furthermore, Parkinson et al. (1982) performed a statistical analysis on individual estimates of PM and SM in two out of five different measures they employed to assess PM and SM capacity. What they observed, was that both PM and SM estimates and the proportion of recency and pre-recency items, were significantly lower in elderly than in young subjects in the immediate free recall task. Yet they found that storage

capacity was higher in PM than in SM in both age groups, which seems to be an artifact of the list length and the measure they used. They also failed to observe an expected interaction between memory storage capacity and age.

Previously, Parkinson (1980) observed an age deficit in a serial memory task. Subjects were given strings of digits that varied in length from trial to trial and they were asked to recall the last five items, starting with the terminal item. No age difference was found for the terminal item, but differences started to increase from the next-to-last item and extending through the other three.

It seems that the data just discussed is not strong enough to favour or rule out the presence of a memory impairment either in PM storage capacity or in the proportion of items recalled from the recency portion of the serial position function in elderly subjects relative to young adults. With that in mind an experiment was designed with two aims:

Firstly, it seemed worth-while to test the claim that PM storage and the proportion of recency items was lower in elderly than in young subjects. To increase our knowledge about ageing differences, an immediate and delayed condition in the free recall (FR) paradigm was included, since all previous claims on age deficits have been based only on the immediate free recall paradigm. Adding a delayed recall test would give a baseline to assess age deficits in long-term memory.

Secondly, recency effects have been obtained in the

continuous distractor paradigm, which do not seem to rely heavily on PM storage capacity. In the CD task each to-be-remembered item in a list is preceded and followed by a period of about 15 seconds of interpolated activity. When at the end of the presentation of the last to-be-remembered item in the list subjects are asked to free recall the items presented, a recency effect is normally observed. It seems very doubtful that the superiority of the last few items in the CD task has come from a short-term or primary memory store.

Therefore, the continuous distractor paradigm seemed to be most appropriate to separate the effects of recency from those of PM store capacity by comparing data from FR and CD tasks. Immediate and delayed recall conditions were also included, although delayed recall in the CD task does not seem to affect differentially the recency portion of the function (e.g., Glenberg et al. 1983).

The other important difference between FR and CD tasks is the amount of processing resources needed to carry out each of these tasks. CD tasks are more effortful than FR ones, since the temporal length of a sequence of to-be-remembered items can be as much as seven times longer in absolute terms. In addition, the requirement to perform an interpolated task may affect the rehearsal of to-be-remembered items more strongly in elderly than in young.

Thus assuming that the elderly have less processing resources or are more sensitive to the demands of difficult memory tasks, an interaction between tasks and recall

performance could be expected.

METHOD

SUBJECTS: Forty-eight subjects from the APU subject panel were selected and divided into two age groups. The average age for the young group was 28.7 (sd: 6.0) and for the elderly group 62.7, (sd: 6.3). In the young group the variable sex was balanced, but in the elderly group only nine men performed the experiment. The average Mill Hill raw scores for each group was respectively 33.0 for young (s.d., 4.4) and 34.3 for elderly (s.d., 5.1). All subjects were tested in the laboratory and seemed to be in good health.

DESIGN: Two different tasks were used: the free recall task (FR) with immediate (I.FR) and delayed free recall (D.FR) conditions and the continuous distractor paradigm (CD) with immediate (I.CD) and delayed free recall (D.CD) conditions. There were four experimental sessions attended by 12 different subjects, each session comprising half young and half elderly subjects. In each session four random word lists were assigned to each one of four conditions, thus at the end of the fourth session all 16 lists had been rotated to each of the four conditions.

In order to balance the temporal length of each condition, each list was preceded in the FR task by 96 two-digit addition tasks and in the CD task, each word was

preceded by six equivalent arithmetic tasks. On the two delayed conditions, the 60-seconds recall task, was preceded by six arithmetic tasks. The recall test was prompted by the sentence: "Please recall the words".

MATERIALS: A total of 292 words were randomly selected from Gilhooly and Logie's (1980) word pool by means of a PDP 11/60 computer. These words were selected according to two main restrictions: the length was 4-7 letters and the Thorndike and Lorge (1944) frequency was between 30-50. In the Gilhooly et al., (1980) word pool, words are also rated according to other variables. Although I do not take pains to match those variables among lists, it has been got roughly the following averages for each word list: imagery 5.0, age-of-acquisition 3.5, concretness 4.8, familiarity 4.8, with all ratings in a 7- point scale, and uncertainty 0.3.

The words were assembled randomly into sixteen 16-word lists, firstly by the computer, then by us, in order to prevent either word repetitions or more than three identical initial letters in each list (*). Two 8-word lists from the total number selected were also chosen for two practice trials. The interpolated task was made up of either 96 or six arithmetic operations, where two digits from zero to nine were presented together (eg. 2 * 9 - two, nine), and subjects were required to add them up and write down the result in an appropriate rectangle of their booklets. All the materials

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(*) The word lists are reported in the Appendix.

were tape recorded in a female voice for auditory presentation at a 2-seconds rate.

PROCEDURE: After entering the experimental room, subjects were informed that the experiment consisted of a memory and an arithmetic task and that they will be scored on both tasks. They were also reminded that they should balance their efforts and attention to both tasks. Then subjects were given two practice trials, one for each paradigm in the delayed recall condition. At the end of the two practice trials further remarks about the way to write down the results of the arithmetic tasks and recall of the words were given for about two minutes. Following that, the experiment started with the presentation of 16-word lists and recall tests. There was an interval of about 5-seconds between each list, and about 10 minutes between the 8th and the 9th list. During this 10-minute interval subjects completed the the Mill Hill vocabulary test.

RESULTS

1. Total Recall

Percent number of words recalled in each two age groups on the free recall and the continuous distractor tasks are presented in Table 1.1. Analysis of variance performed on the total mean number of words recalled between Groups (e.g.,

young and elderly subjects) and Tasks (e.g., I.CD, D.CD, I.FR, D.FR) showed that percent recall was significantly higher for young than for elderly subjects, [$F(1,46)=20.15$, $p<.001$], and was influenced by task conditions [$F(3,138)=21.07$, $p<.001$]. Further analysis using the Newman-Keuls test showed that in the young adults all tasks differed significantly from each other at the $p<0.01$ level, while in the elderly no significant differences occurred between either the two CD tasks or the D.FR and D.CD tasks.

Recall performance was in general poor. Depending on task condition young subjects recalled between 30% and 38% of all words (i.e., about five words per list) while the elderly recalled between 21% and 30% (i.e., about four words per list).

Table 1.1

Percent number of words recalled for each two age groups in each four task conditions

Subjects	D.FR	D.CD	I.CD	I.FR
Young	30	32	35	38
Elderly	21	22	23	30

Note: I. (Immediate recall); D. (Delayed recall). CD (Continuous distractor task); FR (Free recall task).

Meanwhile the rank order of the four tasks was the same for each age group, D.FR, D.CD, I.CD and I.FR. Free recall tasks yielded the highest (I.FR) and the lowest (D.FR) recall performance.

The average number of general intrusions was almost identical in young (3.3) and elderly (3.5) and did not differ across conditions, but the ratio between intrusions and total recall was eight percent higher in elderly than in young subjects. Such a result does not support the claim that the elderly are more conservative than young subjects when setting a criterion for responding.

2. Serial Position Data

Serial position functions for young and elderly subjects are presented in Figure 1.1. The results exhibited clearly primacy effects in all conditions, and recency effects in the two CD task conditions and in the I.FR condition, as expected. Analysis of variance was performed, the factors being the two Age groups and Serial Positions at the primacy (1 - 3), middle (4 - 13) and recency (14 - 16) portions of the serial position function. The Anova was performed for each separate task condition.

The main effect of Age was significant at the primacy segment in both CD task conditions, I.CD - [$F(1,46)=10.4$, $p<.01$] and D.CD - [$F(1,46)=8.4$, $p<.01$], but not in the FR task conditions. In the Middle segment, Age was significant in all conditions, I.CD - [$F(1,46)=10.8$, $p<.01$],

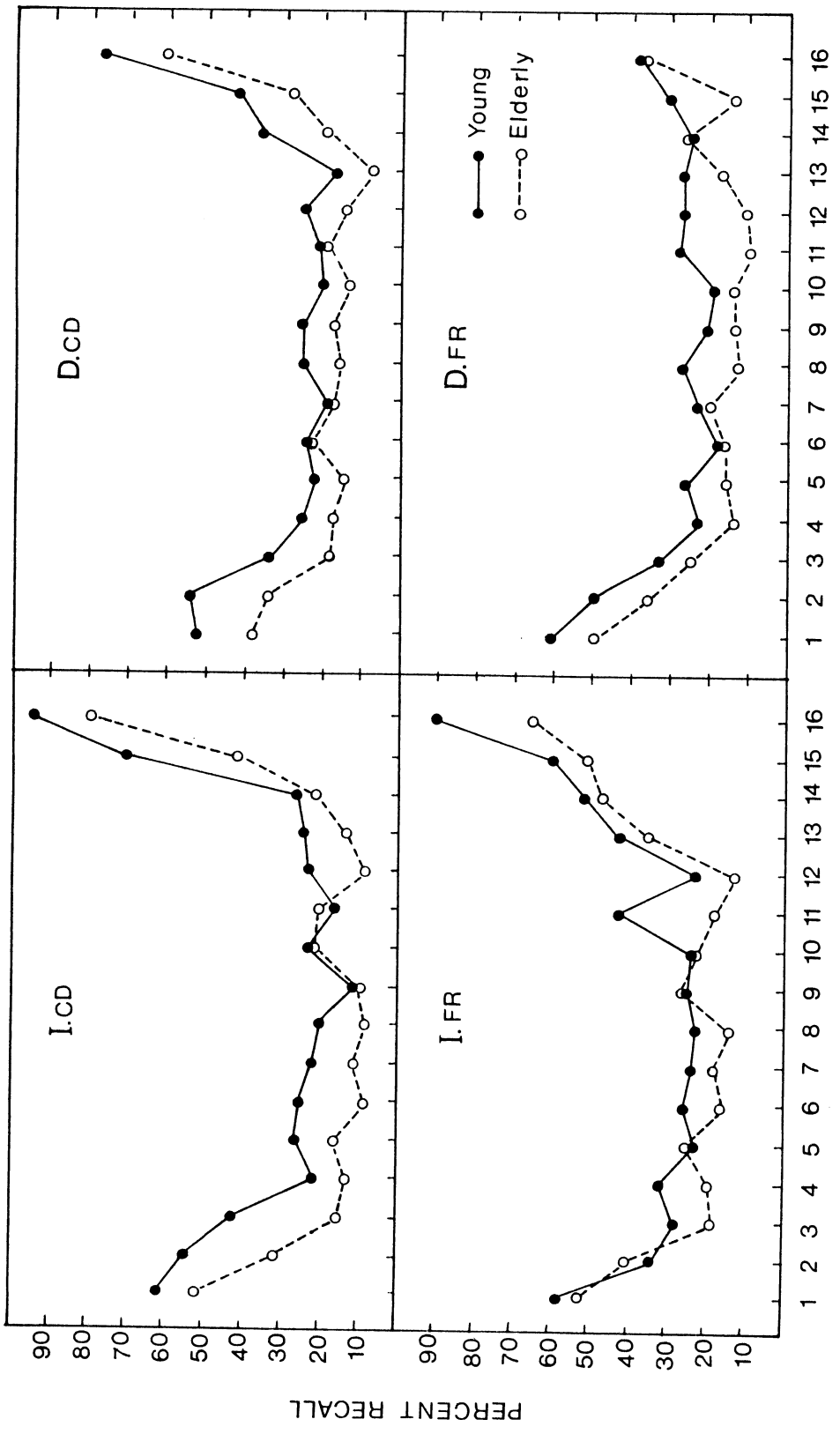


Figure 1.1

Percent correct recall as a function of serial positions for young and elderly subjects in each four task conditions. I. (Immediate recall); D. (Delayed recall); CD (Continuous distractor task); FR (Free recall task).

D.CD - [F(1,46)=6.0, p<.05], I.FR - [F(1,46)=11.0, p<.01], D.FR - [F(1,46)=12.4, p<.01]. At the recency portion of the curve, Age was significant for the following task conditions I.CD - [F(1,46)=14.0, p<.001], D.CD - [F(1,46)=8.4, p<.01], I.FR - [F(1,46)=6.8, p<.01], but not for D.FR task with p>.19. In summary, the Anova showed that the only tasks where age differences were absent, were FR tasks at the primacy segment and the D.FR task at the recency segment.

The main effect of Serial Position was highly significant (p<.001) at the primacy segment of the function in all four task conditions. The same pattern held for the recency segment, even for the D.CD condition. It seems that the 12 - second distractor task presented during the retention interval was insufficient to abolish the recency effect completely. The main effect of serial position for the middle segment of the curve was not significant in all but the I.FR condition. This spurious result was certainly due to the enhanced recall at serial positions 11 and 13. I do not found any explanation for such result.

Interactions between the two main effects (Age X Serial Positions) were not significant in any four tasks at primacy or in the middle portion of the function. At the recency segment, a significant interaction between Age X Serial Position was obtained for the I.CD task [F(2,92)=4.5 p<.01]; F-ratios were marginally significant for the I.FR and D.FR conditions (.05<p<.10).

Age differences as a function of serial position become clearer to understand when recall performance is pooled

together for each segment of the serial position function. Table 1.2 shows that age differences are located in all three portions of the serial position function in the CD tasks and in the middle portion of the FR tasks. In the I.FR condition there is also an age difference at recency but not at primacy.

Table 1.2 still shows that the CD tasks seem to be more sensitive to age differences than the FR task. In addition, the main differences between young and elderly subjects are located in the CD tasks, either at primacy or at the recency portion of the serial position function.

Table 1.2

Percent recall differences favouring young relative to elderly subjects at primacy (1-3), middle (4-13), and recency (14-16).

Task conditions	Serial position segments		
	Primacy	Middle	Recency
I.CD	20 ***	08 ***	16 ***
D.CD	17 ***	07 *	16 ***
I.FR	04	08 ***	13 **
D.FR	11	10 ***	06

Note: Significant percent differences at $p<.006$ for (***); at $p<.01$ for (**); and at $p<.05$ for (*).

3. Primary and Secondary Memory Capacity

Several methods have been employed in the past to estimate primary memory (PM) and secondary memory (SM) capacity, including Waugh and Norman (1965), Tulving and Patterson (1968), Baddeley (1970), Tulving and Colotla (1970), Watkins (1974) and Glanzer (1982).

Parkinson et al. (1982) employed the first five of the the above methods and showed that estimated measures of PM and SM were similar amongst the methods utilized. Therefore, in this experiment, the Tulving and Patterson (1968) method was selected since it seemed to be the easiest to compute PM and SM values. In the Tulving and Patterson method, PM capacity is the average of the last four serial position list items, and SM the average of all remaining items, that is, the average of the first 12 items in the present experiment.

Estimations of PM and SM size are shown on Table 1.3. The individual PM and SM estimated scores were subjected to a four factor ANOVA with two Age groups (young and elderly), two Memory measures (PM and SM), two Tasks (CD and FR) and two Recall Procedures (immediate and delayed).

Three of the four main factors were highly significant: Age, [$F(1,46)=19.9$ $p<.001$], with higher values for young than elderly subjects; Memory Store, [$F(1,46)=108.1$ $p<.001$] with SM higher than PM values; Recall Procedures, [$F(1,46)=47.3$ $p<.001$], with immediate recall higher than delayed recall.

The main factor Age interacted only with Memory Store,

[F(1,46)=6.03 p<.02]. In young subjects the gap between PM and SM was much larger (1.9 - 3.5) than in elderly subjects (1.4 - 2.4). Other significant interactions observed, were between Memory Store and Recall Procedures, [F(1,46)=29.8 p<.001], and Tasks X Recall Procedures, [F(1,46)=24.7 p<.001]. The three-way interaction between Store, Task and Recall Procedure was marginally significant [F(1,46)=3.5 p=.07].

Simple-effect analysis were performed to examine in more detail the previous trends and it was revealed:

Table 1.3

Mean number of words estimated in PM and SM stores for young and elderly subjects according to Tulving and Patterson (1968) method.

	PM			
Age	Task conditions			
	I.CD	D.CD	I.FR	D.FR
Young	2.2	1.7	2.5	1.2
Elderly	1.6	1.2	2.0	1.0
	SM			
	I.CD	D.CD	I.FR	D.FR
Young	3.5	3.5	3.7	3.6
Elderly	2.2	2.4	2.8	2.4

Note: Maximum PM and SM sizes are four and 12 words.

1. Anova carried out between Age and Memory Store revealed that memory store capacity was higher in young than in elderly subjects, either in PM [$F(1,46)=15.9$ $p<.001$] or SM [$F(1,46)=15.0$ $p<0.001$.

2. Anova performed between age groups for each task condition has shown that in PM store all but D.FR conditions were statistically significant, I.CD - [$F(1,46)=16.3$, $p<.001$], D.CD - [$F(1,46)=9.4$, $p<.01$], I.FR - [$F(1,46)=6.15$, $p<.02$], D.FR - [$F(1,46)=3.3$, $p=.08$]. Similar analysis for SM produced significant age differences in all conditions, I.CD - [$F(1,46)=12.9$, $p<.001$], D.CD - [$F(1,46)=8.2$, $p<.01$], I.FR - [$F(1,46)=7.1$, $p<.01$], D.FR - [$F(1,46)=13.6$, $p<.001$].

3. In the PM store, immediate recall produced higher values than delayed recall, both in young and elderly subjects, $p<.001$. In the SM store, the effect of delay yielded F-ratios that were less than one in both age groups. These analyses confirm the assumption that PM store is affected by the recall procedure.

4. The significant within-factors interaction between Tasks and Recall Procedures was examined more closely for both young and elderly subjects and for PM and SM stores. The interaction between Tasks and Recall Procedures remained significant at $p<.01$ in young and elderly subjects in PM, and unexpectedly in elderly in SM. However, in the young group the interaction was less than one in SM. These analyses indicate that recall procedures affect PM in both age groups and they suggest a similar influence on the elderly for SM. In the elderly the gap between CD and FR tasks in SM store was

2.2 and 2.8 in immediate recall, and 2.4 and 2.4] in delayed recall.

5. The significant interaction between Memory Store and Recall Procedures was also examined closely for each age group. The analysis revealed that the interaction between Memory Stores and Recall procedures remained significant for both young and elderly subjects at $p<.001$ in both age groups. In the young group the gap between PM and SM was smaller in immediate recall (2.3 and 3.6) than in delayed recall (1.5 and 3.5). In elderly the gap between stores was again smaller in immediate recall (1.8 and 2.5) than in delayed recall (1.1 and 2.4).

6. Finally, the Newman-Keul test revealed that the differences in means presented in Table 1.3 between the task conditions for PM, in both young and elderly subjects, differed significantly from each other at $p<.01$ level. In SM all means differed significantly from each other at $p<.05$ level, between immediate recall conditions, but not between delayed recall conditions for each age group.

In summary, age deficits are located both in PM and SM stores. For immediate recall, PM was smaller in elderly than in young subjects (less 0.6 words recalled); For delayed recall, SM was also smaller for elderly (less 1.2) than young subjects.

4. Output Order

Thus far a significant age deficit was found in the PM

and SM stores. Yet, it might be argued that differences in the PM store could have been due to different strategies related to different output orders of the words at the beginning of the recall test. If one of two age groups started to recall the list-words from the last output serial positions and the other group did not, then such strategies may have emphasized any observed storage deficits.

Therefore, an examination of the recall sheets was taken to determine if the first, second or third word output by subjects at recall had been presented at the primacy, middle or recency portion of the serial position function.

The results of the analysis of output order of the first word revealed that in the immediate recall conditions of the FR and CD tasks, young subjects recalled more often from the recency portion than elderly. In the I.FR task, for instance, young subjects recalled 48% of first-output words from the recency portion and only 29% from primacy, while elderly recalled 34% and 41% respectively. A chi-square analysis performed on this data revealed a significant effect [$X2(1)=3.9$ $p<.05$]. In the I.CD task, the younger recalled 75% and 15% for recency and primacy and older subjects 60% and 25% respectively. The chi-square analysis was also significant [$X2(1)=4.2$ $p<.05$]. In the delayed recall conditions of FR and CD tasks the origin of the first word was similar in both age groups with all differences observed smaller than four percent.

The results on the output order of the second and third word were equivalent (e.g., differences less than 6% in

all portions) in all but the D.CD task. In the D.CD task the data of output order for the second word showed that young subjects recalled 12% more from recency than elderly, and that the older subjects recalled 15% more from the middle than the younger subjects. A chi-square analysis showed a significant result [$X2(1)=4.7$ $p<.05$]. The pattern of output order was reversed for the third output word. Here elderly recalled 11% more from recency and 16% less from primacy than did the younger group, [$X2(1)=5.9$ $p=.02$].

Data were also analysed to observe if subjects shifted their strategy in the course of the experiment. Thus the output order of the first eight lists was compared with the last eight at the primacy and recency for both age groups. Considering the recency portion firstly, young subjects recalled more recency presented words (i.e., more 49 words) in the second part than in the first part of the experiment and the increment was three times larger for the CD than the FR tasks. In elderly, the increment was clear-cut in the I.CD task (i.e., more 14 words), negative in the D.FR task (less 11 words) and mixed in the remaining conditions. As far as the primacy portion is concerned there was not any major increment or decrement in words recalled in the second part by young subjects, while elderly recalled substantially more words in the D.FR task (19 words) and less in I.CD and I.FR tasks (less 24 words in both).

Finally, age differences found in PM store capacity, and shown on Table 1.3, were the largest for I.FR, I.CD and D.CD conditions and the smallest and non-significant for the

D.FR condition. In addition, data from output order indicated that in the D.FR task young and elderly subjects followed the same recall order, but a different one in I.FR, I.CD and D.CD tasks. I suspect that in such circumstances, the specific output order adopted by each subject had a detrimental effect in elderly and a beneficial one in young subjects in PM storage capacity.

5. Analysis of the Recency Effect

The recency effect and the primary memory capacity have been estimated with such similar procedures in the past that some investigators still regard them as equivalent values. However, both phenomena are logically quite distinct, recency is an empirical phenomenon and PM is a theoretical construct. Since one of the purposes of this experiment was to assess if the size of the recency effect interacted with age groups and task conditions, two different types of measures were determined:

1. The average proportion recalled in the last three serial position points (i.e., 14, 15, 16); the Tulving and Patterson's (1968) measure of PM.

2. Slope estimates obtained by using the least-squares regression line from individual scores on serial positions 14, 15 and 16.

3. Slope estimates obtained by using the least-squares regression line from the terminal four serial position scores for each subject. A slope measure to estimate

the recency effect was adopted by Glenberg et al. (1983).

4. The expected value for the 18th serial position point obtained by using the least-squares regression line from the 14th, 15th and 16th serial position scores. This 18th value takes into account, both the slope and the intersection point values and it was thought that it might be a reliable alternative measure for the recency function.

Measures two, three and four are related estimations of slope values. These measures were adopted to establish a dissociation with PM values (measure 1). It was thought that a high slope value expressing a clear and robust recency effect may not be related with the average proportion of the last three or four items recalled. There are subjects, who sometimes recall perfectly the last three items, therefore exhibiting a very low slope, in contrast with a high PM size. It seems that the peculiarities of recency and PM estimations must be taken more carefully into account, when differential studies are being carried out.

Values from each measure were obtained from each individual and then subjected to analysis of variance to discover any age deficits in each measure. Analysis of variance performed on each four measures between age groups have shown that age differences were highly significant on measure one, the PM measure - [$F(1,46)=16.2$ $P<.001$] and on measure four - [$F(1,46]=10.5$ $p<.01$]. Age differences were marginally significant for the slope measures two [$F(1,46)=3.6$ $P=.06$] and three [$F(1,460=3.8$ $P=.06$].

These analysis seem to suggest that slopes are steeper

in young than in elderly subjects in all slope measures regarded. Yet, measure four seems more reliable, as a recency measure, by taking into account both slope and intersection values, to determine an age deficit on the size of the recency effect.

Anova on the recall performance of the recency portion was also performed between the three Recency conditions (I.CD, D.CD, I.CD), two Age groups and the three Serial Position points (14, 15, 16). The F-ratios obtained were significant for all three main effects at $p<.001$. However, the important data to look at are a significant interaction between Serial Positions and Tasks [$F(4,184)=10.11$ $p<.001$] revealing that recall performance at the terminal three serial positions is dependent on the type of task used; and the overall significant interaction [$F(4,184)=2.48$ $p<.05$], which means that recency data is dependent upon the influence of task features and the age of the subjects.

Looking at differences between young and elderly in each last four serial position points, it was found that age differences were mainly located on the last and next to last serial positions, although data are not uniform for all three recency conditions. In the I.FR task the major difference is located in the terminal item (*), whereas in the CD conditions, the differences were largely spread across all terminal four serial position points.

(*) The age deficit at the terminal item in the I.FR task seems a puzzle. (Cont. next page)

6. Linguistic Influence

Other correlations were performed between Total Recall, Mill Hill scores and Age groups. In young adults, there was a significant Pearson correlation between Age and Total Recall, [$r=0.46$, $p<.05$], and Mill Hill scores and Total Recall, [$r=0.53$, $p<.01$]. However, when the influence of Mill Hill scores were partialled out, the correlation between Age and Total Recall became insignificant, [$r=0.37$], but the correlation between Mill Hill and Total Recall remained significant [$r=0.46$, $p<.05$]. It seems that within the young group the influence of age is less relevant than Mill Hill scores to predict total recall.

In the elderly group, the only significant correlation was between Age and Mill Hill scores, [$r=0.45$, $p<.05$]. This value increased to [$r=0.53$, $p<.001$], when the influence of Total Recall was partialled out. The correlation obtained between Mill Hill scores and Total Recall was [$r=0.30$ $p>.05$],

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(Cont.) Elderly subjects are impaired in the terminal item 25% in the I.FR, compared with 14% in the I.CD task, although the two terminal items are followed by a recall test about one or two seconds later. It might happen that the clues for guessing the presentation time of the terminal item were clearer in the CD than in the FR tasks. Subjects wrote their arithmetic tasks in the left side of an A4 page in each one of 16 lines with six columns each. In the CD task, subjects could have a clear clue to anticipate the recall period, but they were unable to get any clues in the FR tasks, where the left side of each page was filled in with 96 additions previously to the presentation of the first word in a list. Wright (1982) found that the percentage of age loss in recall performance was 15% at recency, 31% in the middle and 11% at primacy in the immediate free recall task. She used 12-word lists and observed, as we did in our experiment that the smallest age difference in immediate free recall was for primacy items.

but when the influence of Age was partialled out, a significant correlation between those two values, [$r=0.43$, $p<.05$] emerged.

It seems that, either in young or in elderly group, recall performance might be related to Mill Hill scores within each group. These analysis may suggest that one of those factors that sustain memory impairment in elderly subjects is their linguistic knowledge or education level.

Discussion and Conclusion

The main findings of this experiment are:

1. A significant age difference favouring young adults was observed in all three main portions of the serial position function in the CD task conditions and at the middle portion in FR conditions.

2. CD tasks were shown to be significantly more sensitive to age deficits than FR tasks, with the deficit located mainly at primacy and recency portions of the serial position function.

3. PM and SM store capacity was smaller in elderly than in young subjects in the Tulving and Patterson's (1968) measure, with the age difference larger in the SM store. In addition, an interaction was observed between age and memory store capacity, with the difference between the two stores being larger for younger than older subjects.

4. It was found that output order could have been responsible to some extent for the age deficits observed in each store.

5. An overall interaction between age groups, tasks and recency conditions was observed at recency, suggesting that age differences are smaller for FR tasks than for CD ones. These differences may support the assumption that the CD tasks are more demanding to perform than the FR tasks.

6. Total recall at each age group is to some extent correlated with Mill Hill vocabulary test scores.

Recall performance has revealed an age deficit on several measures taken in this experiment. One of the measures was primary and secondary memory capacity. Elderly subjects showed larger differences in SM than PM. As far as the PM store capacity is concerned, it has replicated the Arenberg (1976), Salthouse (1980), Parkinson et al. (1982), and Wright (1982) results, where evidence was given that both the recency size and the PM capacity was smaller in elderly than in young subjects. It was also obtained evidence showing that the elderly impairment was much higher in SM than in PM, which seems to be more in agreement with earlier studies (e.g., Craik, 1968) but in fact contradicts Parkinson et al. (1982) results. Yet, the results show an interaction between age and memory store, which was absent in the Parkinson et al. (1982) data.

According to Waugh and Norman (1965) and Atkinson and Shiffrin (1968) models, PM was regarded as the size of a temporary buffer store, where items, after entering the store, are kept for rehearsal and transmission to the SM store. An age deficit in PM could mean that either the elderly engage in smaller amounts of rehearsal activity or they devote less attentional resources to the temporary buffer store, thus reducing its working memory size. Whatever the mechanism responsible, both would explain a smaller SM size in elderly. The present data does allow to choose between each of them.

The second measure takes into account recall performance at the three segments of the serial position

curve. Here large differences were obtained at primacy and recency in the CD tasks and in the middle portion of all four task conditions. As reported at the beginning of Chapter one, each three segments are affected by different variables, and if an age deficit is produced, one or more variables could be assumed to be related to the deficits observed. However, the variables affecting each segment have been investigated within a model derived from the free recall paradigm, and the model can not be generalized to the continuous distractor paradigm, unless some further assumptions are made. Even so, it seems that some other factors, such as output order and rehearsal activity may account partially for the deficits obtained.

In this experiment, it was found that the larger age differences observed in store capacity were associated with larger differences in output order from the recency portion of the serial position function. When elderly followed the same output order as young subjects did, performance differences were largely reduced, as it was observed with PM estimates in the D.FR task. However it is not clear why output order affected so deeply SM estimates, or the primacy portion in the CD tasks in elderly. In contrast, verbal rehearsal can not be checked directly, and its possible influence derives from the larger differences observed at the primacy segment of the CD tasks. Yet, how can verbal rehearsal be extended to the middle and recency segments in order to account for age deficits?

Birren and Renner (1977) and Salthouse (1980) argued

that older subjects process, encode and store verbal information, in much the same way as younger adults do, but at a slower rate. In other words, older subjects perform less well, because they are slower, that is, they take longer to rehearse to-be-remembered items than younger subjects. Thus, the lower recall performance observed throughout the serial position could be the result of a slower rehearsal rate.

Although a speed-loss mechanism can broadly account for the present data, it does not explain either why age deficits are mainly located at primacy and recency segments, or the interactions observed between age and memory stores, and age and tasks at the recency segment of the function.

An alternative hypothesis to account for larger primacy and recency deficits in elderly in the CD tasks would argue that elderly are less able to take advantage of context elements associated with beginning and terminal items. Underwood (1977) demonstrated that the influence of context in the serial position function is largely limited to the first and terminal items (i.e., word lists in his experiment). In addition, Burke and Light (1981) reported evidence that older subjects are less able to retain information about contextual information than younger adults and also that it is more effortful for them to remember non-semantic contextual elements.

Therefore, the larger age deficits obtained at primacy and recency could have been due to older adults remembering less contextual information associated with terminal items or

being less able to utilize contextual cues at recall. If this is true, this experiment extends the scope of such explanation by claiming that the elderly deficit to process context is associated with the more effortful processing tasks, but not with the easier ones.

Finally, ageing research has suggested that the elderly are not only less able to process semantic information to a deeper level, but it seems they are also less capable to process non-semantic material, such as context. In addition, and contrary to Hasher and Zacks (1979) claim, context is not automatically processed, at least in elderly, as other studies showed (e.g., Kausler and Puckett, 1981) and this one may suggest, especially when context is associated with effortful tasks.

CHAPTER 7: The Effects of Ordinal Cues on List Recency with Highly Categorized Verbal Material.

7.1. Experiment 2
7.2. Experiment 3
7.4. Experiment 4

SUMMARY

This chapter presents three experiments that explore the circumstances in which long-term recency effects can be observed in the laboratory in the presence of highly similar verbal material. Four, six or ten lists of words were selected from the category 4-footed animals and learned for immediate recall. After a short retention interval subjects were required to recall as many words as possible from all lists. Total recall functions for four and six lists indicated that recall performance for the terminal lists was not very much different from the asymptotic level. However, when an attempt was made to control encoding deficits, a list recency effect was obtained with highly categorized material. The data were discussed according to the view that recency relies on ordinal retrieval cues. Contrary to some investigators, it is argued that list recency can be obtained in the presence of a strong semantic cue.

EXPERIMENT 2

Long-term recency effects have been observed in two major experimental tasks: the continuous distractor paradigm and total recall of word lists. Both tasks were used by Bjork and Whitten (1974) in their original paper on long-term recency effects, although the continuous distractor paradigm has received much more attention among investigators ever since. Both recency tasks have equivalent mechanisms to control the effects of the two main variables, that can affect the size of the recency effect: rehearsal of each to-be-remembered item in one hand and the ratio of interpresentation interval to retention interval on the other.

It was reported in Chapter two, that the improvement of the last few items was open to several interpretations. To some, recency was due to trace strength; others attributed recency to the rehearsal of to-be-remembered items during the retention interval; and still others to contextual similarities between the context presentation of terminal items and the recall test phase. To be fair, there seems to be no clear way to adopt one interpretation, while being able to exclude all the others, especially when arguing with results derived from the continuous distractor paradigm.

Initially the major role of the long-term recency effect and the continuous distractor paradigm, where the long-term recency effect was derived, was to dispute the argument that recency represented the output from a primary

memory or temporary buffer store. The challenge was successful and nowadays very few people believe that the recency effect is related to primary memory capacity. In that case, what role does long-term recency effect play in the memory system? Are recency effects in short and long-term memory equivalent phenomena or not? In general, investigators have tried to dodge such question, and their main concern has been to explain which mechanisms could have been responsible for the long-term recency effect.

The claim I want to put forward is that the continuous distractor paradigm is inadequate as a testing ground to find out the mechanisms responsible for long-term recency effects. Therefore, and as an alternative recency task, the total recall of word lists was adopted for carrying out my own experiments. Total recall of word lists comprises the presentation of several lists of words for immediate recall. When the end of the recall period of the last presented list is reached, a short retention interval is given followed afterwards by an unexpected total recall of all words from all lists.

Total recall of word lists has several advantages relative to the continuous distractor paradigm:

Firstly, it is hard to claim that the recency effect observed is due to the rehearsal of words from the last few lists;

Secondly, it is acceptable to adopt the assumption that the strength of the traces of the last few lists have reached an asymptotic level when the total recall test was

given and therefore that a trace strength hypothesis can be ruled out. Therefore explanations to account for long-term recency effects will have to be found elsewhere. In other words, total recall of word lists, as a paradigm to investigate long-term recency effects restricts the number of the interpretations available.

Thirdly, variables that have been manipulated in the continuous distractor paradigm can be manipulated in the total recall of word lists, without losing any of their major features;

Finally, and in contrast to previous advantages, the continuous distractor paradigm is easier to carry out and takes a smaller amount of time to complete. It was certainly these latter features that appealed to the investigators, whenever it was chosen.

Meanwhile, it could be argued that the continuous distractor paradigm coupled with an incidental test could have the same success, as the total recall of word lists. In general terms, the point is correct. In a strict sense, the experience tells me that it is much more difficult to find out subjects who are totally naive about an incidental recall test. In a way or another, most naive subjects, especially if they are students, become suspicious about disguised ways to test their memory and they may engage in strategies more typical of an expected recall test. In the total recall of word lists the stratagem to conceal the presentation of a total recall test is more successful, since subjects have already been tested for immediate recall and they have less

reason to suspect another recall test.

Total recall of word lists was used by Bjork and Whitten (1974), but, as far as I know, it was never adopted thereafter to investigate recency. Bjork and Whitten (1974) gave subjects eight lists of 10 word-pairs each. At the end of each list presentation, subjects were asked to recall as many words as possible, and after the recall of the last list there was a two minute debriefing period followed unexpectedly by a final recall test for all words from all lists. A large recency effect was observed, without any concomitant primacy effect. This same pattern was replicated in their third experiment with only four word-lists.

A similar list recency finding had already been obtained by Tulving and Psotka (1971) in a final total recall of word-lists, varying in number from two to six, and with 24 words each. These investigators suggested that the impairment in recall performance of earlier lists relative to later ones was largely due to the unavailability of higher order units.

Bjork and Whitten's (1974) original study was mainly concerned with determining the main boundary conditions of recency in LTM tasks. Since then, most of the studies utilizing the continuous distractor paradigm have been carried out to investigate the role played by different interpretations that could account for the effect (e.g., Glenberg et al. 1980,1981, 1983)

Nowadays, there is a large consensus among investigators that long-term recency effects are mainly due to mechanisms operating at the retrieval stage, rather than at

acquisition or encoding. Some of these mechanisms had already been single out. Murdock (1960) claimed that serial position effects could be the result of higher distinctiveness of terminal items relative to middle list items. Shiffrin (1970) and Ebenholtz (1972) suggested that recency, as well as primacy were the result of positional cues attracting the search process to the beginning and end of a list. Baddeley and Hitch (1974, 1977) suggested that recency resulted from ordinal information, not yet completely degraded for the most recent items; Bjork and Whitten (1974) assumed that retrieval was based on the temporal distinctiveness of adjacent items according to a Weber-Fechner ratio between retention interval and interpresentation interval. Glenberg et al. (1983) claimed that recency resulted from similarities of context-components between the presentation of terminal items and the test-phase.

The experiments to be reported in this chapter examine only one of the mechanisms mentioned above, that is, the effects of ordinal information or temporal order cues. In addition, attempts were made to explore the role played by other mechanisms, such as output order, and the expectancy of a total recall test, on recency.

There is an extensive literature on order information, which usually tries to address two issues: (1) Whether or not item and order information are registered in a separate or common location. (2) Whether or not both types of information are affected by the same or different variables. In general,

several studies have shown that order information is more impaired with high than low similarity materials, either when they are phonological similar (e.g., Horowitz, 1961; Conrad, 1965) or semantic similar (e.g., Baddeley, 1966a; Crowder, 1979). It is assumed that, with high similarity materials, most features are overlapping among items and subjects find it more difficult to encode distinctive cues associated with order information. In contrast to an impairment in order information, there is an item recall advantage for high similarity material, especially with semantic and categorized material. Here common features among the to-be-remembered items are fewer and thus well retained, and can act as effective retrieval cues for recall.

The series of three experiments to be reported in this chapter were designed to examine long-term recency effects in a total recall test with high similarity items drawn from the same category membership. The words selected were 60 four-footed animal names divided into four 10-word lists in the first experiment. With an experimental design like this, two different sets of predictions can be made.

Firstly, according to order similarity literature, ordinal or temporal cues would be degraded to such an extent that a recency effect would be unlikely to occur, if word-materials were drawn from only one category. In addition, data by Tulving and Psotka (1971) revealed that, when subjects were provided with higher order units or category membership, the recall superiority of the most recent lists relative to earlier ones was abolished. Therefore,

these two sets of empirical data would predict an absence of recency for lists with categorized verbal material.

Secondly, if the previous prediction is correct, then the boundary conditions of the recency effect have to be extended. Bjork and Whitten (1974) argued that the long-term recency effect was observed in long-term memory tasks, whenever rehearsal of list items was prevented and the to-be-remembered items constituted a well-ordered series. Data from their third experiment revealed that a recency effect was obtained with four lists at the end of the experimental session, but not 24 hours later. According to Bjork and Whitten (1974), the lists presented during the session constituted a well ordered series from the subjects' point of view, but no longer after a long delayed recall. In the experiments I am going to report total recall is presented at the end of each experimental session, and there are good reasons to believe that by then the sequence of lists still constitutes a well ordered series for the subjects.

In summary, are the boundary conditions, formulated by Bjork and Whitten (1974) to account for recency, robust enough to produce a list recency effect, even when the lists are made up of highly similar materials? Or, in contrast, is recency sensitive to the point of being disrupted, when order information in which it possibly relies is degraded by similar categorized material?

Data from a pilot study, designed to test context effects related to posture, may give some clues about the outcome of such an experiment. Four 15-word lists selected

from 4-footed animal names category were presented to two groups of nine subjects each. Immediate recall was required at the end of each list. At the end of the session subjects were asked to recall all the words from all lists. Percent recall for each four lists were respectively 45, 47, 51 and 61% for subjects, who had been sitting down during the experiment, and 47, 51, 51, 51% for the other subjects' group who had been standing up during the session. In the sitting down group there was a significant list effect, [$F(3,24)=3.2$ $p<.05$], which means that for this group a long-term recency effect was observed in the presence of similar and highly categorized material.

However, the outcome of all conditions is not totally clear-cut. There is no way to know if the absence of recency in the standing up group was due to the type of materials used, or to subjects posture. Since posture is not a variable to be tested in the present series of experiments, there are some good reasons to believe that list recency could be obtained with high similar material, since the boundary conditions for obtaining the long-term recency were present. Therefore, a list recency effect from highly similar material was taken for granted and it was decided to manipulate other variables that could disrupt the list recency effect.

In the first experiment to be reported the other variables manipulated were the output order and the effects of prior recall learning. If list recency was obtained in the presence of highly categorized material, it could be argued that output order could have facilitated to some extent the

emergence of list recency. An analysis of the pilot study data suggested that one of the reasons for the absence of recency in the standing up group was due to a larger number of words being recalled from earlier presented lists at the beginning of the total recall test.

Therefore in the first experimental group, no instructions about output order were given. Subjects were simply asked to recall as many words as possible from all lists. It was assumed that subjects in this group would start recall, mainly from the fourth list, the most recent one.

In the second and third groups, output order was covertly disrupted by providing subjects with extra retrieval cues, which could sample small sets of words scattered throughout all lists. In the second group, extra cues were given at the beginning of the total recall test, and in the third group one minute before the end of the recall period. If extra cues were successful in disrupting output order, they would be more effective, while the retrieval plan was being set up at the beginning of the test (Group 2), than when it was given later in the recall period (Group 3). Therefore it was expected that groups one and three would not differ in the size of the recency effect, in contrast to an expected disruption in group two.

A fourth group was run to investigate the effects of prior recall learning. There is evidence that a recall test in a verbal learning situation acts in much the same way as a further learning or study-phase. Studies have shown that total recall performance for lists previously recalled is

higher than for lists not recalled before, Trow (1928), Raffel (1936), Postman and Phillips (1961), Donaldson (1971), Darley and Murdock (1971). It is not clear whether recall of word-lists not previously tested would show a list recency effect or not. Assumptions based upon Bjork and Whitten's (1974) boundary conditions would predict a list recency regardless of prior testing. In fact the size of recency should be larger, since the amount of item rehearsal was much smaller in the fourth group. Assumptions based on material similarities would not predict any major effect either positive or negative on list recency. Thus, the inclusion of the fourth group was an exploratory attempt to collect data on the effects of prior recall on list recency.

METHOD

SUBJECTS: Forty-eight subjects from different departments of the University of Oporto took part in the experiment individually or in groups of up to three subjects each. Almost all subjects were participating for the first time in a memory experiment and were paid for their services. Their age ranged between 19 and 30, (mean = 23.7, and S.D. = 2.5). There were 26 males and 22 female subjects.

DESIGN: There were four groups of 12 subjects. Each subject was assigned to one of the four groups randomly according to the entry order in the experimental room. In the

immediate recall, all four groups were presented with four 15-word lists and treated in the same way except at recall. Within a group each subject was assigned to one of the four different list orders according to a latin - square design. The first three groups had a recall test at the end of each list presentation and the fourth group was asked to generate names of different countries up to 15 within each recall period (*).

In delayed recall, groups one and four were asked to recall as many animal names as possible in any order they wished from all four lists presented earlier; groups two and three were asked to do the same, but subjects were reminded that the animal names to be recalled could be smaller or larger, pet or wild, from cold or warm habitats. These instructions were given to the second group right at the beginning of the total recall test, and on the third minute to the subjects in the third group.

MATERIALS: Sixty words from the 4-footed animal

(*) The first four subjects who ran this condition considered the task very odd. Their frustration and disappointment was visible, because, as they told, they thought they were going to take part in a memory experiment. It seemed to me they were not very well committed to the requirements of the task and they were later discarded from the analysis. So new instructions were given to subjects in the fourth group. They were told that I was interested to know how many countries they knew, and listening to animal names, they would be able to elicit the names of some countries, due to specific links between animal habitat and areas of the Globe. They were told that, in order to prevent bias, they will be given more information about the purpose of the experiment at the end of the session. These instructions did fortunately work out much better.

category were selected. These words were then divided into four 15 - word lists and matched according to frequency. It was taken into account, either the Battig and Montague (1969) frequency study and a pilot one with Portuguese university students. These students rated each word within a list and then each list according to frequency (*).

Each 15 - word list was presented twice in a different random order and at the end of each study phase, eight 3 - digit numbers were given. Subjects were required to subtract three from each and to write down the answer in their booklets. The 3 - digit number and the subtraction result was always in the same ten, thus the first two digits remained always invariant. The word lists and digits were tape recorded in the experimenter's voice and presented at 2 - second rate.

PROCEDURE: After entering the experimental room, subjects were informed about the tasks they were going to carry out, and reminded that in order to prevent experimental bias no further information would be given until the end of the session. Then, subjects were given a practice trial consisting of one list of 15 uncategorized and highly familiar words, followed by eight 3-digit numbers. In the test phase, subjects were required to recall as many words as possible in any order they wished from the previous list for 60 seconds The recall period was prompted and ended up by the equivalent

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(*) A list of the words selected is presented in the appendix.

Portuguese sentences: "please recall the words" and "end of recall". There was an interval of 90 seconds after the practice trial which was filled with further information about the experiment and the tasks. No interval between lists was given other than the time to say the number of the new list (1st, 2nd, 3rd and 4th list).

At the end of the fourth list recall test, subjects were required to deal two packs of playing cards into 12 sets as fast as possible. Six sets were for diamonds and hearts (reds) and the other six for clubs and spades (the blacks). Each six sets were made up of all 2 and 3, 4/5, 6/7, 8/9, 10/Q, K/K. This task took on average at least 3' 30'' to complete and those few subjects, who finished earlier, were asked to check each 12 sets for mistakes.

When three minutes and 55 seconds had elapsed, a message from the tape recorder was unexpectedly delivered, asking subjects to recall as many animal names as possible from all four previous lists. Subjects were told that they would be warned on the third minute about the elapsing time with the prompt "third minute", and no more information was given to Groups one and four. Group two was given some retrieval cues at the beginning of the recall period immediately after listening to the message on the tape recorder and Group three was given the same retrieval cues immediately after the warning "third minute", in both cases by the experimenter.

RESULTS

Due to the lack of any frequency measure for categorized 4-footed animal words in Portuguese, the immediate recall and total recall data were firstly analysed to observe any effects of order on list presentation by a latin - square Anova. In immediate recall F-ratio for group effects was less than one, and the F-ratio for order effects was [$F(3,96)=1.06$, $p=.35$]. In total delayed recall, the F - ratios for groups were [$F(3,32)=1.06$, $p=.38$] and for order [$F(3,96)=1.64$, $p<.18$]. These analysis suggested that any fears about the four word lists being unmatched for word frequency in Portuguese were unfound and could be discarded as irrelevant presuppositions.

The recall performance for groups in immediate and delayed recall is shown on Table 2.1. The immediate recall data was subject to an Anova (three groups x four Trials) and the only significant difference observed was for trials [$F(3,99)=17.91$, $p<.001$]. As expected a large build up of proactive interference was observed across trials. The groups did not differ among themselves [$F(2,23)=1.13$, $p=.33$].

The total delayed recall data is the important one to look at. Analysis of variance between the three Groups that have experienced an immediate recall test and the four Trials was performed. It was found that the groups did not differ, $F < 1$, although the differences among lists were almost significant [$F(3,99)=2.57$, $p=.06$].

TABLE 2.1

Mean number of words recalled in each four lists in immediate and total delayed recall in different recency conditions

Immediate recall

Groups	========== L I S T S =========					
	1	2	3	4		Mean
Group 1	8.9	7.3	7.9	6.5	-	7.7
Group 2	10.0	8.4	7.7	6.8	-	8.2
Group 3	8.6	7.3	6.8	6.6	-	7.3
Mean	9.2	7.7	7.5	6.6		

Total recall

	1	2	3	4		Mean
Group 1	7.3	6.0	7.3	7.6	-	7.0
Group 2	8.1	6.8	6.7	6.8	-	7.1
Group 3	6.8	5.4	6.6	7.1	-	6.5
Group 4	5.3	4.4	3.8	4.3	-	4.4
X (1,2,3)	7.4	6.1	6.8	7.1		
X (1,2,3,4)	6.8	5.6	6.1	6.4		

Note: Group 1: No cues given; group 2: cues given at the beginning of total recall; group 3: cues given on third minute; group 4: neither immediate recall required nor cues given.

Since the average recall was higher on the fourth list than on the third, and this one higher than on the second list, an Anova between the terminal three lists was performed to test if there was a significant recall increment. In fact, the F - ratio obtained did not approach significance, [$F(2,66)=2.37$, $p=.10$]. It seems that performance on the total delayed recall test was almost a flat function with a small drop in recall performance on the second list.

DISCUSSION

The results of this experiment have shown that long-term recency effects in a total delayed recall for lists with categorized verbal material were not very strong. Although Groups one and three did show a trend towards a list recency effect, the results of Groups two and four reversed the trend observed in the other two groups, showing more evidence of primacy rather than recency.

Although list recency is not a strong effect, the data do not rule out its presence. Since the predictions based on Bjork and Whitten (1974) boundary conditions suggested clear recency effects in Groups one and three and maybe four, while predictions based on similarity of categorized material and the presence of higher order units suggested an absence of recency in all groups, especially in Group two, the evidence seems to lean more towards the effects of similarity than

towards boundary conditions. Wherever the truth lies, it seems that categorical similarity had a negative effect on list recency, either by degrading order cues on which recency is based or by increasing item accessibility from earlier lists.

An interesting point in this experiment's data was a trade off between list recency and list primacy list effects. In Groups one and three recency list was enhanced, while in Groups two and four primacy was stronger. The only explanation that it was possible to come up to account for such trade off was based on the effects of output order. It is well known that recency is sensitive to output order in STM tasks, although there is a lack of evidence about such effect on LTM tasks.

In Groups one and three, the only retrieval cue available at the beginning of the recall test was the general category of 4-footed animals. Subjects may have thought that this cue would not help too much, and it would be better to rely on the materials presented and recalled more recently and work back in time. On the other hand, subjects in Group two, had further retrieval cues in addition to the general retrieval category on which to set up a different retrieval plan. In this case, words from several lists rather than from only the terminal list were accessed and sampled.

In summary, it seems possible that subjects in Groups one and three relied on the recent past to access their memories. In contrast, subjects in Group two may have discarded such a recency strategy due to the emphasis by the

cues given.

Analysis of output order confirmed these suspicions. Each subject's total number of words recalled was divided into four quartiles. If, for instance subjects 1 and 2 had recalled 20 and 28 words from all lists, the first five and seven words were assigned to the first quartile for subject one and two respectively. An analysis for the first two quartiles, has shown that subjects in Group one recalled more 18 words from list four than from list one, and in Group three they recalled 10 words more. In contrast, subjects in Group two and four recalled eight words more from the first list than from the fourth one.

The main conclusion to be drawn from the data of experiment one is that, unless output order is taken into account, no strong claims can be made about the effects of categorical similarity. Similarity effects may degrade order cues and thus the recency effect on which it is dependent, but output order has no less influence on long-term recency effects after all.

We must also bear in mind the fact that the majority of subjects were participating in a memory experiment for the first time. Learning and recalling list one could represent greater distinctiveness and be a more memorable experience for naive subjects than for experienced ones. Therefore primacy effects could be more salient, when data is plotted for list position than for input serial position across all four lists.

Experiment two did not indicate, if the failure to obtain a significant list recency effect was due or not to

material similarities. After a summer holiday, when the previous experiment took place and back at APU, I thought it was worth running another experiment to cast further light on this issue.

EXPERIMENT 3

Experiment three was designed to explore again the presence of list recency with highly categorized material. Four-footed animal names were selected again, but they were divided into six 10-word lists rather than four lists. Although previous investigators have obtained a large list recency effect with only four lists (e.g., Tulving and Psotka, 1971; Bjork and Whitten, 1974) it was thought that a reduced number of lists would not produce a clear asymptotic level for middle lists, against which primacy and recency effects could be compared.

The other variables introduced in the present experiment were an intentional and incidental total recall test in one hand, and an intertrial interval between lists in the immediate recall presentation on the other.

There are several studies on the effects of incidental and intentional learning, largely investigated in immediate recall. Estes and DaPolito (1967) found that subjects performed significantly better on an intentional test than on an incidental one with a paired-associate learning task with lists of eight CVC-digit pairs. In contrast, Hyde and Jenkins (1969) presented subjects with lists of 24 words and asked them to perform some orienting tasks. Half the subjects in each orienting task were informed they would be later asked to recall the words. In the incidental learning conditions, subjects were not told they would have to recall the words.

In addition a control group was told to memorize the list for later testing. The results indicated that incidental and intentional learning was almost identical, provided that subjects in the incidental learning conditions processed the meanings of the words (e.g., pleasantness).

It was expected that the manipulation of an expected (intentional) or unexpected (incidental) total recall would affect the rate of rehearsal. Subjects had small breaks during the experiment to allow extra-rehearsal if they wished. One such period was during the immediate recall test, when there was sufficient time to recall the previous list and to process the items just recalled for a later test. The other was during the retention interval. In these circumstances, the Group expecting a total recall test at the end of the session had the opportunity for extra rehearsal activity during the experiment and therefore to increase recall performance of earlier and middle lists relative to a Group not expecting the final recall test. Therefore list recency should be larger in the unexpected (incidental) total recall group, than in the expected (intentional) group.

The intertrial interval was manipulated to avoid a possible criticism about the experimental design. It may be argued that even if total recall performance across lists is a flat function, the ratio of total recall to immediate recall reveals a strong recency effect. In other words, the amount of learned material, expressed by the ratio of total recall to immediate recall in terminal lists is much higher than for initial lists.

For instance, in the previous experiment, the ratio between total over immediate recall for lists one to four was for group one:

.82, .82, .92, 1.16

This increment across lists is related to the fact that terminal lists in immediate recall are subject to larger proactive interference effects and thus to encoding and retrieval deficits than earlier lists.

The build up and release of proactive interference effects have been investigated mainly in the Brown-Peterson short-term memory task. Loess and Waugh (1967) found a decrease in proactive interference with an increase in the intertrial interval between lists. When the interval exceeded two minutes, proactive interference had almost disappeared and a flat function was obtained. Underwood and Freund (1968) found also that temporal separation in a paired-associate paradigm reduced markedly proactive interference effects. They further suggested that proactive interference could be due to a loss of list differentiation along the temporal dimension.

There are at least two other studies, Cermak (1970) and Kincaid and Wickens (1970), where evidence was given that list differentiation in short-term memory tasks is a critical process involved in reducing the impact of proactive interference. With that in mind, it seemed worth establishing an equivalent recall performance across lists in immediate recall by disrupting proactive interference effects. Therefore an intertrial interval of 60 seconds between

successive lists was selected. For control purposes another group with a "0" seconds intertrial interval was introduced.

Increasing the intertrial interval had two purposes: Firstly, a larger intertrial interval would disrupt the build up of proactive interference, thus producing more equivalent recall performance across lists; Secondly, it would increase the ratio of interpresentation interval to retention interval. In this case it was expected that the size of the recency effect would be larger for 60-seconds group than for 0-seconds one.

In summary, since an unexpected or expected total recall was also manipulated, the size of recency should be the largest in a 60-seconds unexpected total recall Group, and smaller for the other two groups, the 60-seconds expected and the 0-seconds unexpected Groups.

In the present experiment and after completing the total recall test, a total cued recall and a list discrimination test was also given. The purpose of the cued recall test was to observe if the size of list recency would be affected by presenting extra-cues or subcategories from the general category of 4-footed animals. There is evidence, that long-term recency effect is largely disrupted when a cued recall is given, Glenberg et al. (1983).

As far as the list discrimination task was concerned, it was assumed that, if a list recency effect was observed, then it was more likely that subjects would identify list membership more easily for recent lists when a larger (60 seconds) intertrial was given than not.

A list discrimination task is difficult to perform, being much more difficult when category membership is repeated across lists. Winograd (1968) observed that the words correctly recalled were not necessarily correctly assigned to one of the two lists used in his experiment.

METHOD

SUBJECTS: Forty-eight subjects from the APU subject panel were selected. There were 20 males and 28 females and their ages ranged from 20 to 40 years old (mean: 32.7 and S.D.: 6.9)

DESIGN: Three groups, to be called 0-Unex, 60-Unex and 60-Ex, with 16 subjects each, were assigned to the independent variables in this experiment. The digits "0" and "60" mean the elapsed time between the end of a test recall from list "n" and the beginning of "n+1" list presentation. In the two "60" group conditions there was a 60-second digit search task. In the "0"-group the digit search task was omitted. "Unex" and "Ex" attributes represent the unexpected and expected total delayed recall test.

The independent variables were the presence or absence of an interval between two successive lists and the expectation of a total delayed recall or its absence. Thus the 60-Unex group was the control group both for the 0-Unex

group to test the effects of list separation and for the 60-Ex group to test the effects of differential encoding due to the expectation of a total recall test. In the 60-Ex group subjects were instructed at beginning of the experimental session that a recall test of all 4-footed animals would be required at the end of the session.

The list order was counterbalanced according to a latin-square design and two subjects were assigned to each order. Due to the appearance of one exceptional subject in one group and the need to increase the validity of the results, four more subjects were further tested in each group and four different list orders were assigned to them.

MATERIALS: The same materials used in experiment two were used again and divided into six equivalent lists of 10 words each according to their frequency. Ten words from the category birds were also selected to make up the practice list.

Seven lists of eight pairs of digits (e.g., 5/8, 9/7, etc.) were selected for the filler task to be presented before the immediate recall test. Subjects' task was to add them up and to write down the result before the presentation of the next digit-pair (e.g., 13, 16, etc.). The materials were tape-recorded in a male voice for auditory presentation and both words and digit pairs were presented at a 2.5 seconds rate.

Seven sheets of single random digits were made up and subjects were required to search and to cross out in each line

all "0"s during the practice trial and digits 1, 2, (...), 6, after the correspondent immediate recall test of list 1, 2, (...), and 6.

List numbers (1,2,3,4,5 and 6) occurred several times during the learning of each list. Firstly, when the list was presented, its identification number was given. The list number was also given prior to the recall test of the list. Thirdly, at the end of each recall test, subjects had to search for a digit, which was always identical to the number of the list just presented. Finally, the 60-EX group was informed about the occurrence of a list identification test at the end of the session. The purpose of all this was to establish an opportunity for associations to develop between items and list order.

PROCEDURE: After entering the experimental room subjects read a set of typed instructions. They were told that a series of six 4-footed animal lists would be presented auditorily, and after a short arithmetic task, they would be asked to recall as many words as possible for 45 seconds. The 60-Ex group was also told that there would be a total recall test of all 4-footed animals followed by a list identification test at the end of the experiment. All subjects were informed that most of the 4-footed animals were mammals, although a few were reptiles.

After recalling the sixth experimental list or at the end of the digit search in the "60 group" condition, subjects were engaged in a task of reading digits from 0 to 9. This

task completed the first half of the experiment. Next, all subjects were required to recall as many 4-footed animals as possible from the six lists presented earlier. They were then asked to recall the 4-footed animal words with the help of several sub-categories or cues. Subjects were told that several cues would be given in order to trigger off more 4-footed animal words. Subjects were told that the 4-footed animals presented could be divided into reptiles and mammals. Mammals into smaller (e.g., rodents), or larger ones, mainly domestic, farm animals and wild, and that the habitat of most of them could be the jungle, Africa and Asia, national parks, forests, zoo.

When the total cued recall test was ended, all sixty categorized words were presented in alphabetical order and subjects were required to identify which list each animal name had been presented in, by circling one of six digits. Subjects were asked to guess if necessary and not to spend more than three-to-five seconds per word.

In the 0 and 60-Unex groups subjects were asked if the total delayed recall was totally unexpected or not for each of them. Everybody said it was. Almost all subjects were tested individually; the others in groups of two.

RESULTS

The results are presented in Table 3.1. In the immediate recall test the means of the 60-Ex and 60-Unex groups do not differ, $F < 1$, as well as between the two Unex groups, [$F(1,30)=2.94$, $p=.10$]. As I have predicted, the interpolation of a 60-second filled interval between lists increased the amount of total recall, but it was not enough to produce a significant effect or to disrupt the build up of proactive interference effects in the two "60" groups. Thus the results showed also a significant build up of PI, [$F(5,150) = 8.3$, $p<.001$]. Therefore the 60 seconds interval was not enough to differentiate the two groups in a significant way and to disrupt proactive interference.

In total recall a two-way analysis of variance with three Groups and six Lists yielded two non-significant main effects with F less than one in both cases. Therefore, effects of serial position, intentional total recall as well as intertrial interval were not significant.

In the total cued recall, an equivalent two-way Anova between Groups and Lists produced again a non significant Group effect ($F<1$). In contrast, a significant list effect was obtained, [$F(5,225)=3.1$, $p<.01$]. This list effect was located at the primacy segment rather than at recency. Two-way analysis between total recall and total cued recall for each three Groups produced non-significant F-ratios for the main effect of recall test in all three conditions.

Table 3.1

Mean number of words recalled in each three groups and six lists, on several total retention tests.

Groups	L I S T S						
	1	2	3	4	5	6	Mean
Immediate recall							
0-U	6.0	4.6	4.7	4.2	4.3	3.9	- 4.6
60-U	6.4	5.3	5.2	5.1	4.1	5.1	- 5.2
60-E	6.4	5.8	4.6	5.1	4.8	5.2	- 5.3
Mean	6.3	5.3	4.8	4.8	4.4	4.7	
Total recall							
0-U	4.6	3.3	4.2	4.2	4.3	4.3	- 4.1
60-U	4.6	3.7	4.5	4.1	3.7	4.4	- 4.2
60-E	3.9	4.8	3.6	4.4	3.8	4.6	- 4.2
Mean	4.3	3.9	4.1	4.2	3.9	4.4	
Total cued recall							
0-U	5.2	3.4	4.2	4.1	4.3	3.5	- 4.1
60-U	4.7	3.8	4.1	4.1	3.7	4.3	- 4.1
60-E	4.6	4.7	3.3	4.0	3.6	4.2	- 4.1
Mean	4.8	4.0	3.9	4.0	3.9	4.0	
List discrimination							
0-U	1.4	1.7	1.9	2.4	2.3	1.3	- 1.8
60-U	1.8	2.1	2.1	2.4	2.4	1.3	- 2.0
60-E	1.8	2.4	2.1	1.8	1.8	1.3	- 1.9
Mean	1.7	2.1	2.0	2.2	2.1	1.3	

Note: "U" - Unexpected and "E" - Expected total recall; "0" and "60" - seconds interlist interval.

As far as the variables manipulated in this experiment, the results showed that neither of them had a significant effect on list recency. Although in the two "60" - Groups recall was higher for the terminal list than for the previous one, the recall performance was not very much different from the asymptotic level. A similar recall pattern was reproduced in total cued recall for the same groups at recency. In total recall, small primacy and recency effects were present, but neither was significant. In contrast, total cued recall produced an unexpected list primacy effect. A plausible explanation would suggest that the primacy effect depends more on storage than on a retrieval phase.

The results of the list identification have shown that subjects were unable to discriminate the words of different lists above chance level (i.e., 1.7 words). Although middle lists were discriminated slightly more above chance than the first and terminal lists, such an effect might have been due to subject bias. Whenever subjects were unsure, they guessed that such word must have been presented in a middle list, where the number of identification cues was smaller. This bias certainly increased the likelihood of middle lists being apparently more successfully identified.

DISCUSSION

The variables manipulated in this experiment (i.e., incidental vs intentional recall and two intertrial intervals) did not produce any major effect on list recency in total

recall or total cued recall. The results also revealed no correspondence between recalling a list of categorized words and the ability to identify the words as belonging to that list. Subjects performed at around chance level in the list discrimination task, even in the two "60" groups, where redundant information on list ordering was given. In addition, it was expected that context dependent activity, resulting from the search task and associated with the instructions that subjects in the 60-EX group would be required to perform a list discrimination at the end of the session, should have been sufficient to enhance list discrimination, but they were not.

This experiment and the previous one seem to show that list recency in a total recall test is far from being a strong effect, whenever materials from similar semantic categories are presented. However, the present findings can not be taken as evidence that list recency is simply a conjecture. The data may simply indicates that the absence of a clear and reliable recency effect in these experiments is the result of the particular variables selected.

The evidence supporting this claim is based on the presence of proactive interference effects in immediate recall, even with a 60-second intertrial interval between lists. Obviously a longer interval should have been selected. In addition, instructions suggesting an incidental or intentional total recall test had no effect on performance. It seemed that subjects did not take any advantage whatsoever of short breaks for extra rehearsal, or if they did, the time

spent in such activity was insufficient and ineffective.

It would be premature at the present time to draw any definitive conclusions regarding the existence of a reliable list recency effect with categorized material. My suspicions were based on the fact that subjects recalled an equivalent mean number of words in the two total recall tests. The level of forgetting across lists did not seem to be due to a retrieval failure, since recall performance in the total cued recall was similar to the total recall test. Therefore, a floor effect may have masked the sensitivity of each test. In such circumstances, the absence of list recency could have been due to an encoding and storage deficit, and thus the encoding of ordinal cues among lists was severely restricted. If a learning deficit was responsible for the absence of list recency then there are two ways to prevent that: one is using several study phases for each list, the other is a selection of small lists close to the average word span of 5.5 words (e.g., Brener, 1940).

Therefore a new experiment was designed, aimed at controlling the learning deficit more explicitly.

EXPERIMENT 4

As it was pointed out earlier in this chapter, the major purpose of this research was to assess the role played by ordinal cues in long-term recency effects. The assumption was that, if long-term recency effects were based on ordinal cues, then highly similar materials would reduce the recency effect much more than non-similar materials. The first step to take should have been to select two extreme types of materials according to the semantic similarity level. That step was not taken then simply because it was believed that recency might be obtained with highly categorized material and money and time could be saved if other hypothesis were explored. Since other investigators have shown long-term recency effects with dissimilar verbal materials, it was not thought to re-demonstrate this phenomenon.

However, the data from the two previous experiments suggested that list recency probably is dependent to some extent on the degree of material similarity as well as output order and encoding deficits. Therefore, the present experiment was aimed at testing list recency as a function of material similarity. Subjects were presented with either highly categorized verbal materials (i.e., the sixty 4-footed animals presented in previous experiments) or uncategorized and unrelated words. If list recency was based upon ordinal cues, then the list recency effect should be more disrupted with the former than latter materials, since the similarity

between to-be-remembered items was much larger in the former set.

In addition, attempts were made to control the encoding deficit, as a possible variable influencing recency. To achieve this, the number of to-be-remembered items in each list was reduced to near the word span level and subjects were instructed to establish within each list associations, and to organize word-clusters. Each sixty-word set was divided into ten 6-word lists. It was expected that, if each list organization was successful, the representations and organizations imposed on each list by each subject would be as much preserved for the most recent lists as for previous ones.

By bringing recall performance close to a ceiling level in immediate recall, I also expected that the effects of interference would be minimized and subjects would be less constrained to recall the words from the terminal lists.

Since the way the experiment was designed only required a 30-minute session, and subjects were paid for a whole hour, the spare time was utilized to test the same subjects again with the other set of verbal materials. Therefore the expectation of a total recall was also manipulated, by instructing subjects that a total recall test would be given at the end of the session. Since the expectation of a total recall test was not the major purpose of this experiment, this factor was not balanced between each two half periods of each session.

METHOD

SUBJECTS: Sixty-four subjects from the APU subject panel were tested. Their ages ranged from 21 - 50, with mean: 37.3 and S.D. = 7.9. There were 23 males and 41 female subjects, and all were paid for their services.

DESIGN: The type of verbal materials was the variable manipulated with two levels, categorized versus uncategorized words. In addition, the presence or absence of instructions to expect a total recall test was also tested. There were eight sessions with eight subjects assigned to each session. The list order was not counterbalanced according to a latin-square design, since such design would have required 20 sessions; instead, four random list orders for each type of material were used. In half the sessions, categorized lists were presented first, followed by uncategorized lists on the second half; for the other sessions, the order was reversed.

The instructions preceding each second half session were: "The same task will be repeated again, but with a different category of words. I want to know how learning and memory will be affected by these different verbal materials. The procedure will be exactly the same as in the first half of this session, and right at the end there will be a total recall test".

MATERIALS: The categorized verbal material was the same, as was used in previous experiments. The uncategorized

verbal materials were sixty words from Gilhooly and Logie (1982) word pool selected from the A and AA frequency range, with length four to eight letters. These two word samples were divided into ten 6-word lists. Although it was impossible to match perfectly the average frequency per list in the categorized words, I attempted to work out the best possible match for frequency ratings, making the lists as equivalent as possible (*).

For the uncategorized and high frequency words an attempt was made to prevent any clear associations within each list (e.g., rain, water). This was not so easy to achieve due to the high levels of concretness, familiarity and imagery ratings. In each list, half the words had either A or AA frequency levels. In both categorized and uncategorized lists, all words within a list had different initial letters. For the practice trials, six more words were selected from each type of materials. All words were typed in uppercase and slides were made for each list.

The interpolated activity consisted of 12 arithmetic tasks: four additions, four subtractions and four multiplications in a random order (e.g., 7 + 3; 3 - 1; 9 X 2, etc.). Materials were presented visually by a slide projector and each list sequence was made up of four slides:

(*) Firstly, I distributed the ten animals with lower frequency in each ten lists; Secondly, I followed the same strategy for the next ten animal names less frequent until all ten 6-word lists were filled up. Semantic or size similarities (e.g., rat-mouse, lion-tiger) within each list were avoided. When all ten lists had been prepared, the word sets were then mixed up randomly in each list.

(1) A warning slide with the words "new materials" was presented for four seconds followed by (2) Presentation of a six word list for 12 seconds; Then, (3) presentation of an arithmetic task for 16 seconds; and a (4) "?" indicating a recall period, lasting 22 seconds.

The interval between two successive slides was about 1.5 seconds. When subjects had finished recalling the 10th list, they were required to perform a Stroop task. Seventy slides were presented for about two seconds each and subjects were asked to write down "Y" for yes, when the coloured square matched the word underneath, or "N", in the other case. At the end of this task there was an unexpected or expected total recall test of the words presented earlier. All materials in each slide were presented in white against a blue background.

PROCEDURE: After entering the experimental room, subjects were informed firstly about the main tasks in the experiment: the learning of word lists, the arithmetic tasks and the stroop task. They were told that they will be scored both for their recall performance and arithmetic skills. While performing the arithmetic task subjects were instructed to write down one result underneath the other and to try to look always at the screen in order to perform as many operations as possible.

In order to prevent acquisition and encoding variability, subjects were explicitly instructed that a useful strategy for learning the words would be the establishment of links amongst two or three words within a list. For this

purpose examples were given from the practice trial (e.g., dog, cat (pets); dress, night (night dress), etc.). At the end of the practice trial, there was a 90-second interval, where a few more remarks about the experiment were made. Subjects were then informed that the categorized materials were from the 4-footed animal category, or that the uncategorized words were highly familiar and no problems would arise to recognize them quickly.

After recalling the list ten, subjects were asked to perform the Stroop task followed by the total recall test for four minutes with the warning "third minute" presented at that elapsed time. The second session followed ten minutes later with different verbal materials and an expected total recall.

RESULTS AND DISCUSSION

The results are presented in Table 4.1 for each group, both in incidental and intentional recall. In either half-sessions, the immediate recall tests showed high significant proactive interference effects for categorized words, both in incidental [$F(9,279)=4.2$ $p<.001$] and intentional recall tests [$F(9,279)=4.8$, $p<.001$], but not for uncategorized words $F<1$. Therefore, the encoding deficit was not removed in categorized materials. Recall performance was significantly higher for uncategorized (Mean = 4.0) than categorized (Mean = 3.6), verbal material [$F(1,62)=5.14$, $p<.05$].

Table 4.1

Mean number of words recalled for each ten lists with categorized (C) and uncategorized (U) verbal materials in incidental and intentional recall tests.

INCIDENTAL RECALL

Immediate Recall

	L I S T S										
	1	2	3	4	5	6	7	8	9	10	Mean
U -	4.3	4.1	3.8	4.3	3.4	3.8	4.0	4.1	4.2	4.2	- 4.0
C -	4.4	4.2	3.6	3.8	3.1	3.5	3.5	3.3	3.0	3.6	- 3.6

Total Recall

U -	.9	1.2	1.7	1.5	1.0	1.5	1.3	2.0	2.3	2.8	- 1.6
C -	2.1	2.5	2.1	2.6	1.6	2.4	2.4	2.8	2.3	3.3	- 2.4

INTENTIONAL RECALL

Immediate Recall

U -	4.8	4.4	4.7	4.7	4.5	4.4	4.6	4.6	4.6	4.3	- 4.5
C -	4.5	3.9	3.5	3.7	3.5	3.3	3.5	3.4	3.2	2.8	- 3.5

Total Recall

U -	1.3	1.2	2.2	1.8	1.9	2.3	1.8	2.1	2.2	2.9	- 2.0
C -	2.2	2.3	2.3	2.0	1.8	2.6	2.2	2.7	2.3	2.3	- 2.3

In incidental total recall, a highly significant list recency effect was observed both for categorized [$F(9,279)=3.88, p<.001$] and uncategorized words, [$F(9,279)=6.04, p<.001$] for all 10 lists. A two-way Anova between two types of materials (categorized versus uncategorized) and list serial position (lists 6 to 10) yielded a large list recency for materials [$F(4,248)=6.92, p<.001$], but the interaction between words and serial position was not significant, [$F(4,248)=1.69, p=.15$]. When comparing recall performance between lists one to five with lists six to ten, the average performance was significantly higher for recent lists than for earlier ones, both for uncategorized [$F(1,31)=15.7, p<.001$], and for categorized materials, [$F(1,31)=10.0, p<.005$].

In the intentional total recall, there was a significant list recency effect for uncategorized [$F(9,279)=2.81, p<.01$], but not for categorized materials [$F(9,279)=1.39, p=.19$]. The average recall performance for six to ten lists relative to earlier lists was significantly higher for uncategorized [$F(1,31)=8.4, p<.01$], but not for categorized materials [$F(1,31)=3.2, p=.07$]. The interaction between materials and lists five to 10 was not significant, [$F(4,248)=1.53, p=.19$]. Except for categorized words in the intentional total recall test, recall performance on list 10 was always higher than on list nine.

Finally, combining incidental and intentional total recall performance, there was no difference in immediate recall for categorized material, between incidental

(Mean = 3.6) versus intentional (Mean = 3.5) recall tests, F-ratios less than one. On the other hand, there was a significant difference in uncategorized materials between incidental (Mean = 4.0) and intentional (Mean = 4.5) recall tests [$F(1,62)=7.16$, $p<.001$].

In total recall, categorized verbal material was equivalent in incidental (Mean = 2.4) and intentional recall (Mean = 2.3) F-tests less than one. Uncategorized materials were again higher for intentional (Mean = 2.0), than for incidental tests (Mean = 1.6) and the difference was statistically significant [$F(1,62)=4.70$, $p<.05$]. This type of priming effect, or positive transfer, specific to the uncategorized and highly frequency material, observed in immediate recall and replicated in delayed recall, may be worth investigating further.

Some of the main findings of this experiment are:

(1) List recency or long-term recency is dependent on the type of verbal materials used, being greater for unrelated verbal materials than for highly categorized words. According to the assumption that it is easier to encode temporal order cues with uncategorized than categorized material, the claim that long-term recency effects rely on temporal order cues was to some extent confirmed.

(2) The presence of an incidental or intentional total recall test does not affect the size of list recency with uncategorized materials. In both cases, it seems likely that subjects rely on ordinal retrieval cues in the absence of

other explicit and more powerful cues.

(3) As I correctly suspected in previous experiments list recency can also be obtained with highly categorized material, and the incidental total recall has shown a significant list recency effect. However, the fact that list recency was obtained with incidental, but not in intentional total recall with categorized material suggests that list recency is largely a retrieval phenomenon.

The only large difference between incidental and intentional categorized total recall was on list ten. Since overall recall performance was equivalent in both total recall tests, the superiority of list ten suggests that subjects in the incidental condition set up a retrieval plan based on category and ordinal cues. In contrast, subjects in the intentional condition presumably relied on category cues, since the recall test was expected, and category cues were possibly regarded as more effective than ordinal cues.

GENERAL DISCUSSION

The experiments previously reported were aimed at exploring the idea that long term recency effects could be found in the presence of a strong semantic cue and higher order units.

The results of experiment two and three showed that with a small number of lists and a low to medium learning

criterion, the recency effect was very weak and very often undistinguishable from the asymptotic level. Disrupting covertly the output order in the total recall with extra retrieval cues or manipulating the expectation of a total recall test seemed almost irrelevant, as the results of experiment three have illustrated.

At that stage it seemed that the retrieval plan for the total recall test was exclusively based upon the word category selected by the experimenter. It seemed that subjects discarded any alternative or supplementary retrieval cues, or else that such cues were ineffective. Therefore, explanations ensuring the priority of retrieval plans based on semantic cues and higher order units were able to fit the results (e.g., Tulving and Psotka, 1971).

Meanwhile, I suspected that the results of the first two experiments did not favour a strong long-term recency effect, but they also did not rule it out. Yet, I was puzzled by the observation that total recall and total cued recall were equivalent in experiment three, denoting a learning deficit rather than a retrieval one.

The research then focused mainly at reducing the learning deficit in the study phase of each list. In addition, it was decided to include a control group of unrelated words, where order cues could emerge more easily than with highly categorized verbal materials. The results of experiment four seemed to show that I was in the right track, since long term recency was obtained in the presence of a semantic and strong retrieval cue in incidental total recall.

This result adds to earlier research on this topic.

On the one hand, Tulving and Psotka's (1971) claim that list recency is eliminated when higher order units are given to subjects requires some modification. On the other hand, the suggestion made by Baddeley (1976) that long-term recency is a peripheral and subservient mechanism "to be employed only if better retrieval strategies are not available" (op. cit. p. 185) may not be always right.

The experiments reported in this Chapter are not totally conclusive. More research is needed to test list recency with several types of verbal materials. The data reported suggest that, unless encoding deficits are controlled in immediate recall and output order in total recall, the presence of these variables can mask any genuine list recency in highly categorized verbal material.

When I was reviewing this chapter, Greene and Crowder (1984) reported an experiment to test the effects of ordinal cues on long-term recency, in much the same way as I did in experiment four. They selected two types of materials: (1) Ten lists of semantic similar items with each 10-word list drawn from a new category; (2) The same 100 items rearranged into ten different lists, but with all items within each list completely unrelated by category. The continuous distractor paradigm was adopted and each item within a list was followed by several multiplication problems for a period of either six or 36 seconds. Recall was only required immediately after each list.

The results showed that list recency was greatly reduced by item similarity. However, a list recency effect based exclusively on the terminal item was still present in highly similar lists with a 36-sec interstimulus interval.

Greene and Crowder's (1984) results as well as my own suggest that list recency is based upon temporal order cues, even in the presence of highly similar material.

CHAPTER 8: The Effects of Elapsed Time and Interpolated Events on Memory for Car Parking

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8.1. Experiment 5
8.2. Experiment 6
8.3. Experiment 7

SUMMARY

A series of three experiments on memory for car parking in the parking area of the Applied Psychology Unit was carried out. In the first experiment, members of the APU staff were asked to locate on a map the spot where they had parked during the two previous weeks both in AM and PM. The main purpose was to replicate previous observations of long-term recency effects and to explore the effects of elapsed time and interpolated events.

In the second experiment, members of the APU subject panel were asked after a delay of two hours, one week or one month, where they had parked when they arrived for testing at APU. The recall performance of each group was unexpectedly equivalent in the three conditions reaching the 72% level.

On the third experiment we tried investigate of whether the forgetting observed could be due to proactive (PI) or retroactive (RI) interference. Two groups of the subject panel came twice for testing separated by about two weeks. they were asked one month after the first visit (RI) or the second visit (PI) to locate the correct parking spot. The results showed that the performance in the PI and RI group did not differ. An explanation based upon the temporal discriminability seems to be better suited to interpret the results than does a classical theory of interference.

EXPERIMENT 5

The experiments to be reported were initially carried out to explore the presence of long-term recency effects in naturalistic settings. Techniques such as incidental free recall, questionnaires and word-prompts have been used to elicit everyday and autobiographical memories. These studies, which were reported in some detail in chapter four, revealed among other things, that recent episodes are typically recalled much better than earlier ones.

This recency effect is not easily interpreted, either as the output of a short-term buffer store, the exercise of rehearsal processes, or as reflecting decaying trace strength. In contrast, interpretations based on interference effects and retrieval strategies are regarded as more feasible to account for recency in naturalistic memory studies. The validity of these interpretations is normally tested under laboratory conditions, and for this reason the naturalistic studies are not aimed at reaching such goals. One of the few exceptions was a study carried out by Baddeley and Hitch (1977) on memory for rugby games.

These investigators asked the players of two rugby clubs to recall the names of the teams that they had played against that season. An important aspect of this experiment was the attempt to set apart the effects of elapsed time and interpolated events. The fact that the players had not played all games for their clubs in the season made it possible to

separate the effects of memory "age" from the effects of intervening events. Making this point more explicitly, let us say that for example the player "A" played more often early in the season and player "B" either early or later. Carrying out an experiment like this, it was somehow possible to test if these two players could remember their last game equally well, even if the retention interval since the last game played was different for each player. Recall measures of other events followed by one, two or more games could also be obtained.

The results showed a clear long-term recency effect for both rugby clubs. In addition, correlation and partial correlation analysis were performed between recall performance, interpolated games and the "age" of the games, and the values obtained revealed that the recency effect in this incidental recall task was more a function of interpolated events than elapsed time.

Such separation of factors seemed useful and if an equivalent task was devised, then it could be possible to replicate such findings and to study them more in detail. The first experiment to be reported is such an attempt.

The subjects in the first experiment were members of Applied the Psychology Unit staff. It seemed possible to figure out that not all members would come everyday by car during a specified period, either because they sometimes come to work by bicycle or are engaged in work outside the APU. If this were the case, then testing the last two weeks parking occasions at APU would provide us with a replication of the rugby game experiment. It seemed to us that such research was

useful, not only to increase the data pool of naturalistic memory studies where appropriate tasks for testing long-term recency effects are not always easy to find out, but also to study the differential effects of elapsed time and interpolated events in a naturalistic memory task.

METHOD

Over 12 days, starting on a Wednesday and excluding weekends, the parking spot and the registration number of all cars found inside the private parking or outside near the main entrances to the APU were recorded twice a day at 11.30 AM and 3.30 PM. One hundred and twelve cars were recorded, though less than half belonged to APU staff.

On the 12th day, between 2 and 2.30 PM, a letter and a questionnaire was delivered to all staff, saying that we were interested in memory for - and forgetting of - repeated everyday events and asking them if they were prepared to help us by trying to remember where they parked their cars on each occasion either AM or PM over the last two weeks (*). Enclosed with each questionnaire there was an appended plan of the parking area with 58 numbered spots, and our colleagues were asked to respond "0" if they did not bring their cars on a particular occasion, "/" if they had absolutely no idea where they parked and one or two close numbers (e.g. 57/58), if their cars were for instance parked between locations 57

(*) A copy of the letter, questionnaire and parking map is presented in the Appendix.

and 58.

Subjects were asked to guess if they were unsure and to complete the questionnaire in any order they wished. Subjects were also reminded not to use diaries or external memory aids, and to return it before tea time (4 pm).

Forty one subjects returned their filled questionnaires. Their age was in the 20 - 64 range, with mean, 39.3 and S.D, 11.3. The median was 36, and the 25th and 75th percentiles were 32 and 49. The age function was positively skewed.

RESULTS AND DISCUSSION

On average, the subjects tested had parked on 52% of all possible parking occasions. The number of parking occasions recorded in each of the three 4-day periods was 35%, 34% and 31 percent; it does not seem that the parking behaviour changed significantly across the total period.

Responses were categorized in four ways: into four dependent variables:

1. Accurate responses.

2. Correct responses plus or minus one location. If 51 was recorded, then 50, 51 or 52 were considered correct responses plus or minus one spot.

3. Correct within the same area. If any number within a "natural area" of the parking lot was recorded, then

all response numbers in the same parking area were considered correct. Twelve areas were determined on the basis of clustered spots formed by natural pointers, such as trees, flower-beds, lateral areas and main entries to the APU. Each ten in the parking map refers to a different parking area, hence 50, 51 and 58 would be in the same area, whereas 10, 20, 30 or 40 would be in different areas.

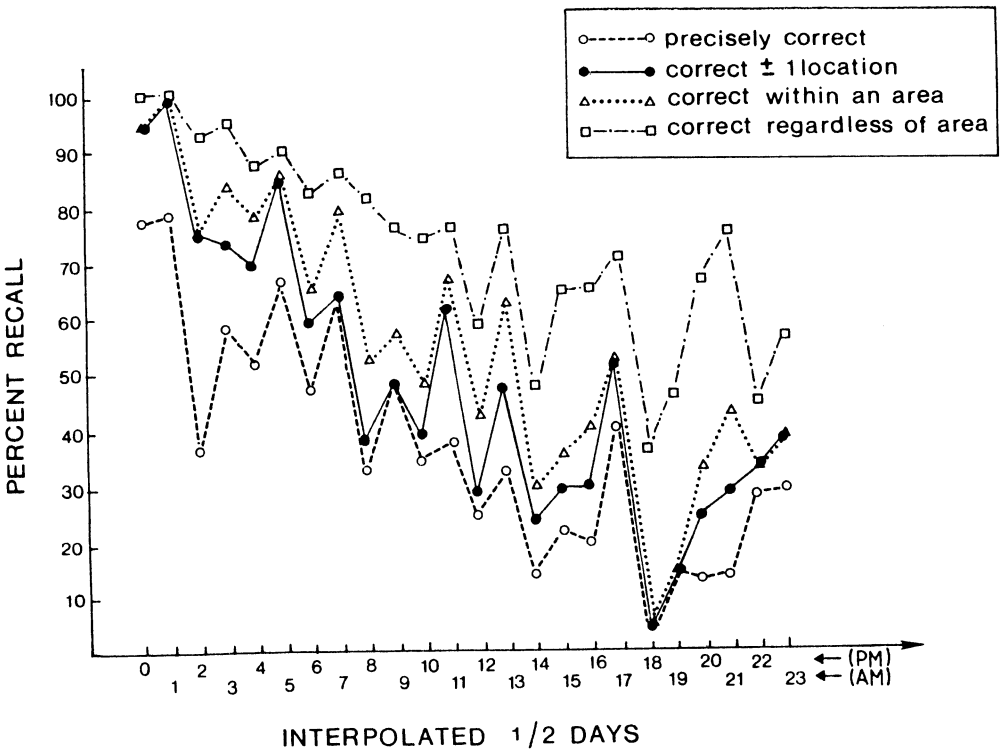
4. Different parking area; if 52 was recorded, then a response with a number from any other ten than 50 would be categorized as a different parking area.

It was assumed that the first three dependent measures estimated how well memory for spatial information was retrieved, and the fourth measure would estimate the memory for temporal information about when subjects came to the APU regardless where they had parked.

Percent correct recall based on each of these dependent measures is presented in Figure 5.1 as a function of intervening days and in Figure 5.2 as a function of interpolated parking occasions. A single within subject factor Anova performed on subjects' performance on each four dependent variables has shown a very high significant effect, [$F(3,120)=23.65$, $p<.001$] for measures. By applying the Newman-Keul analysis, it was observed that all dependent variables differ significantly from each other at $p<.001$.

The recall functions of these two Figures reveal:

Firstly, percent correct recall seems to be a function either of elapsed time, Figure 5.1, or interpolated events, Figure 5.2.



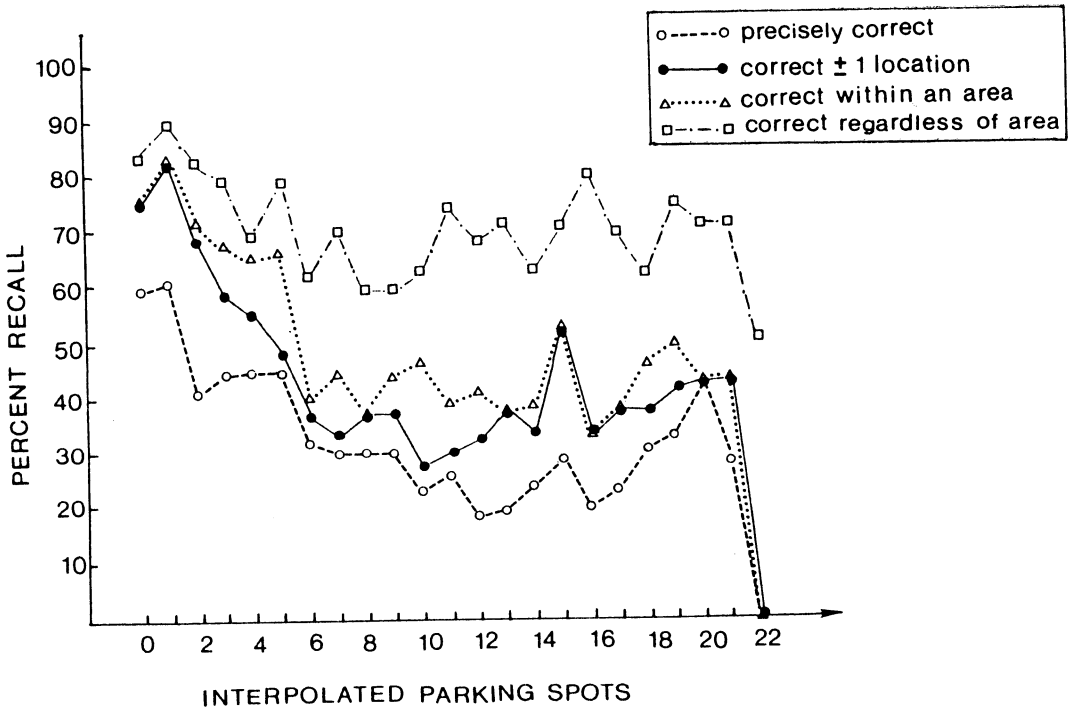


Figure 5.1 and Figure 5.2

Percent recall either as a function of the number of intervening days (Fig. 5.1 - top), or the number of interpolated parking spots (Fig. 5.2 - botton) according to four dependent measures.

In order to tease out the effects of elapsed time and interpolated parking spots on the recency function, estimations of (1) the number of interpolated parking spots, (2) the mean chronological "age" of the parking spot for each subject (i.e., the elapsed time), and (3) the percent correct recall (*) were obtained and subject to correlation analysis.

The results of the Kendal's Tau coefficients were: between 1 and 2 = 0.992; 1 and 3 = - 0.285, [Z = 1.91, p=.06, one tailed], and between 2 and 3 = - 0.293, [Z = 1.95, p = .05]. These coefficients suggest that recall performance is negatively correlated with elapsed time and the number of interpolated parking occasions. However, when the effects of each of the two variables affecting recall performance were partialled out, the correlation values between recall and elapsed time or recall and interpolated parking spots were not different from zero.

Kendal's Tau correlation coefficients were estimated for all 41 subjects at each of 23 interpolated occasions since no subject parked on 24 occasions. This procedure was adopted, because a group of subjects, who came almost everyday and parked invariably on the same spot, showed very good recall. It turned out that their results biased the whole set making the overall correlations meaningless. There occurred for instance in this parking group a positive correlation between percent recall and the number of interpolated events.

(*) The measure selected for further statistical analysis of the results was percent correct recall for "plus or minus one location", (measure 2).

Consequently it was understood that the average data of all 41 subjects at each 23th point was less biased and better balanced than the data of each subject.

Secondly, Figures 5.1 and 5.2 show a pronounced recency effect, both for the spatial (1, 2 and 3) and temporal measures (4), although percent recall declined faster in the spatial variables than in the temporal ones. The recall superiority of the last few parking occasions was tested by giving ranks starting with the most recent parking occasion. Then the mean rank of interpolated parking spots was compared with the mean rank of correct parking spots for each subject.

It was observed that 35, out of 38 subjects who have shown differences, had lower ranks for the correct parking occasions than for their own mean rank of interpolated events. A sign-test has shown a highly significant effect at $p<.001$, suggesting that the correct parking spots had the lower ranks and were therefore the most recent ones.

Thirdly, Figures 5.1 and 5.2 present a few small irregularities although we expected the emergence of some salient Von Restorff (1933) effects. It was thought that the ends of a working week (Mondays and Fridays) and maybe Thursdays, due to a weekly conference held at the APU, would be cases of anchor mechanisms in retrieval. But looking at Figure 5.1 the main irregularity observed was associated with the end of the first week, Friday PM (18) and next Monday morning (17). It is likely that this irregularity was due, not to the end of the week, but to the biggest number of cars recorded on Friday afternoon. Thus, if that Friday (18) was

given an 100% level, recorded cars in all other days were in the 80 - 90% range, except Monday (17 and 16) which was 73% and the following Monday (6 and 7) which represented 61 percent.

In addition, the proportion of subjects who claimed they came by car was compared with the number of cars recorded on these days. The results showed that subjects largely underestimated their parking on Friday (18) with only 47% saying they had come by car, as compared to the following Monday (17) where the percentage rose to 83 percent.

The other major irregularity shown in Figure 5.1 was related with the consistent decline in percent correct recall in the afternoon as compared to the morning parking occasion. This trend was apparent across the entire period, including testing day. The difference between PM and AM was still present, even when the number of correct rejections was added to the correct responses.

One explanation is that subjects had preferential locations for parking their cars that became almost "private" parking spots with the course of time. Due to the absence earlier in the morning of visitors, members of subjects panel or others, it is much easier to find and park in a preferential spot in the morning, than in the afternoon, when the "private" spots may have been already taken, either by visitors or by colleagues.

Signal Detection Analysis

The results were once more analysed according to the signal detection methodology, in order to obtain a function of subjects' discriminability and decision criterion across the 24 parking occasions. Accordingly, the hit rate was obtained from correct responses with plus or minus one spot; correct rejections from "0" responses; the false alarms from all number and "/" responses, which were given against real "0" stimuli, and finally the errors were obtained from all number responses, which were beyond the plus or minus one correct positions.

The entire period of 12 days or 24 recording car occasions were divided into three groups of four days or eight recorded car spots. Hits and false alarms values, as well as the discriminability and criterion values, are presented in Table 5.1.

Table 5.1

Hits, false alarms, discriminability and criterion values for each three consecutive periods of parking occasions.

Intervening Days	Hits %	False Alarms	d'	Log. Beta
1 - 4	79	15	1.84	.22
5 - 8	39	25	.40	.19
9 - 12	27	49	- .50	- .18

The d' primes shown in Table 5.1 reveal that subjects were only able to discriminate the parking occasions more correctly for the latest four days which corresponded to Monday-Thursday of the testing week. The log. beta values also reveal that the higher discriminability values are associated with a conservative rather than a liberal criterion. Everything being equal, subjects took more risks and therefore gave more false alarms as the number of intervening days increased.

Groups with Parking Similarities

Similar and dissimilar parking influenced recall performance, as we pointed out earlier. An interesting question to ask could be how much recall performance and the recency effect would have been affected by repetitions of the same parking spots. There are several studies on the effects of repetition carried out, both in the laboratory and in naturalistic settings. A series of studies have shown that repetition is not enough to increase memory performance significantly, either with laboratory tasks (e.g., Tulving, 1966; Craik and Watkins, 1973) or in naturalistic settings, Bekerian and Baddeley (1980).

In contrast, Geiselman and Bjork (1980) demonstrated that recognition memory was independent of rehearsal time, only when maintenance rehearsal processes were required. If subjects were asked to perform elaborative rehearsal, they would benefit much more from larger than shorter rehearsal

periods.

In another study, Rundus (1980) argued that previous studies which revealed no increase in recall performance as a function of maintenance rehearsal could be suspect, since a limited range of the rehearsal time variable was tested. Rundus' (1980) results showed that overall recall performance increased significantly as a function of the rehearsal time period selected.

Parking in a smaller or larger number of similar spots could be interpreted as a type of repetition or rehearsal activity. Would such repetitions be effective enough to produce higher recall performance? In order to investigate that, subjects' responses were examined to find out two groups with similar or dissimilar parking spots. It seemed a priori that a comparison between two groups, differing on the number of similar parking spots would have to be independent of the total number of parking occasions. The groups that it was possible to establish had the following parameter values:

1. Parking in different spots:

1.1. Similar group, maximum six different spots in all 24 occasions: Mean, 4.0; S.D. - 1.5.

1.2. Dissimilar group, between seven and eleven different spots over the same period: Mean, 8.0; S.D. - 2.4.

2. Equivalent total number of parking occasions.

Due to these main restrictions, two groups of 11 subjects each were selected. The mean number of parking occasions for each group was:

2.1. Similar spot group: Mean, 18.2; S.D. - 5.6.

2.2. Dissimilar spot group: Mean, 17.8; S.D. - 3.6.

These two groups were subject to a t-test in order to see if we could accept the null hypothesis. Since $t(20)=0.18$, $p>.57$, therefore it was assumed that these two groups were matched according to the number of times they parked and their cars were recorded.

The mean recall percent and the mean d' prime values were:

1. Similar group: 62% correct recall; d' = 0.78,

2. Dissimilar group: 31% correct recall; d' = - 0.78.

A t-test performed on d' prime values showed a highly significant value [$t(22)=3.39$, $p<.001$, one tailed]

The percent correct recall as a function of the number of intervening days for the two above groups is shown in Figure 5.3. The gap between the two groups start to increase after the fourth interpolated parking spot. In the similar group performance levels off at about 65%, while in the dissimilar group it is about 15-20 percent.

Putting aside the testing day, the average differences in percent recall between these two groups in the other 11 intervening days were about 46 percent. This large difference was almost certainly due to subjects behaviour in parking in a similar or dissimilar spot.

In order to support the relation between the number of different parking spots and the number of errors, a Pearson

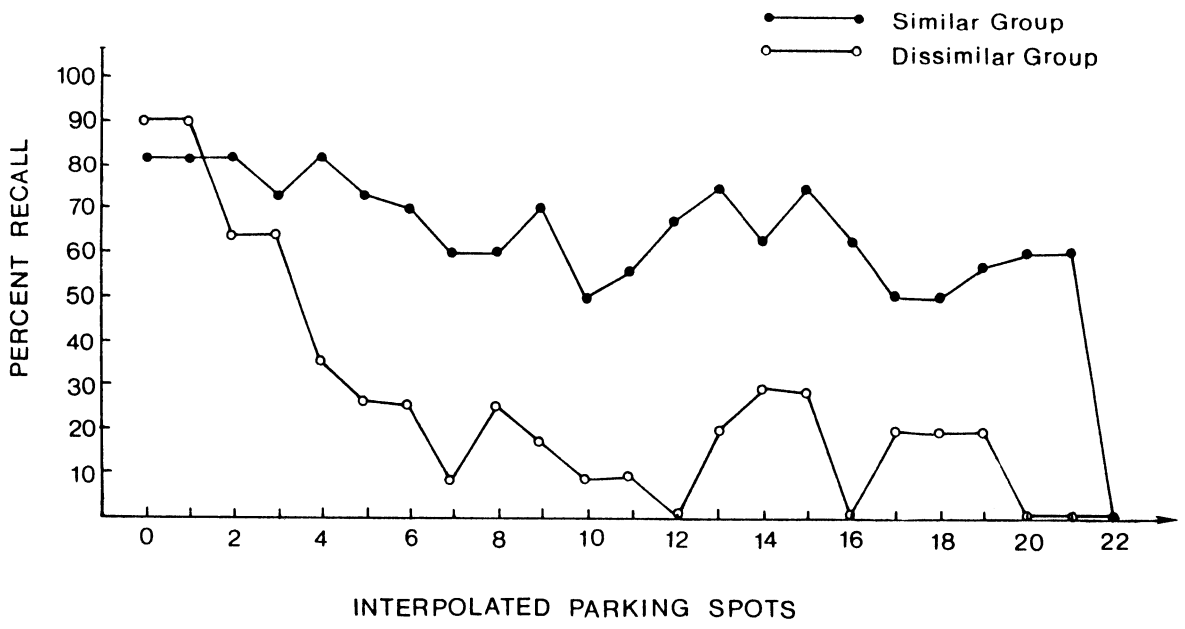


Figure 5.3

Percent correct recall for groups parking in similar or dissimilar locations as a function of the number of interpolated parking locations.

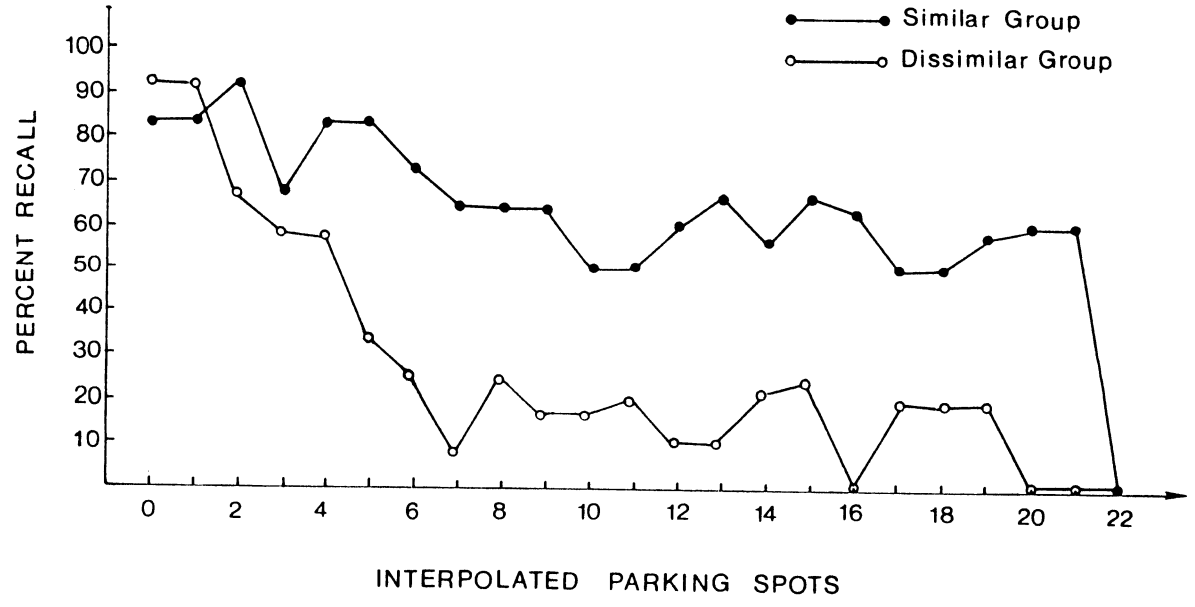


Figure 5.4

Percent correct recall for groups parking, either in similar locations and in AM and PM, or in dissimilar locations and in dissimilar AM and PM.

correlation analysis was performed and the value obtained was highly significant, [$r = 0.85$, $p<.001$]. Therefore, this significant value confirms that recall performance is dependent on the number of different parking spots utilized by subjects over a specific period.

Another aspect of the parking behavior that can affect the results is the tendency that some subjects have to keep their cars everyday in the same spot, in both AM and PM. It was assumed that if a group of subjects do not usually go out for lunch, then their cars will be parked in the same spot in the two recording occasions and therefore they will be subject to less interference than those subjects with different parking in AM and PM.

To investigate this fact two new groups were established with the following parameters:

1. Number of times subjects parked equally in AM and PM each day, the AM = PM value;

2. Number of times subjects parked in AM and PM each day, the AM + PM value;

3. The ratio between the two previous values, AM=PM / AM+PM. A value of one would mean that a specific subject came for instance five times in AM + PM, and parked equally in AM and PM in those five days. A value of 0.2 would mean that, a subject came for instance five times in AM + PM and only parked once in AM and PM equally;

4. Total number of parking occasions.

The criterion to select the similar and dissimilar AM

and PM groups was set at a fraction of the ratio AM=PM / AM+PM. Therefore, it was decided that ratio values equal or above 0.65 would be assigned to a similar group and below 0.65 to a dissimilar parking group. In addition, both groups were matched according to the number of times they parked and their cars were recorded.

The two selected groups had the following central tendency parameters:

1. Total parking occasions,

1.1. Similar parking in AM and PM: Mean, 15.8; S.D., 4.9.

1.2. Dissimilar parking in AM and PM: Mean, 15.6; S.D., 4.0.

2. Ratio AM=PM / AM+PM,

2.1. Similar AM-PM: Mean, 0.91; S.D., 0.09.

2.2. Dissimilar AM-PM: Mean, 0.38; S.D., 0.22.

Percent correct recall and d' prime values obtained for each group were:

1. Similar group: 62% recall; d' = 0.388,

2. Dissimilar group: 36% recall; d' = - 0.575.

The differences between the two groups with similar and dissimilar parking in AM and PM were not so large as between the groups with similar and dissimilar parking spots. Even so there were significant differences either in percent recall and discriminability values. A t-test performed on the data expressed in d' prime values showed that the two means were significantly different, [$t(20) = 2.38$, $p<.01$].

The Pearson correlation value between the ratio

AM=PM/AM+PM and the number of correct responses for each subject was $r = .43$, $p<.01$, therefore confirming the dependence of recall performance upon the parking similarity in AM and PM.

Nevertheless, it must be said that six subjects were common to the two previous similar groups and another six in the two dissimilar ones. After excluding all common names in the two similar and dissimilar previous groups and matching them according to the number of parking occasions, it was possible to set up two new groups with 12 subjects each, whose central tendency measures for parking occasions were:

1. Similar group: Mean, 17.9; S.D., 5.5.
2. Dissimilar group: Mean, 17.0; S.D., 4.2.

The mean percent correct recall for these two latest groups is shown in Figure 5.4. This Figure shows that after four interpolated events, the similar group function starts to level off at about 60%, while in the dissimilar group the asymptote level drops to about 15 percent. The mean d' values was 0.63 for the similar group and - 0.82 for the dissimilar one. A t-test performed on this data showed a highly significant difference, [$t(22) = 3.81$, $p<.001$].

The recall superiority of similar groups can be interpreted in two different ways: On the one hand, results favoured the hypothesis that repetitions of a reduced number of items (i.e., parking spots in this case) increases recall performance. On the other hand, the results support the existence of a mental representation or schema for favourite

parking spots, which due to its encoding characteristics is easily retrieved.

Taken into account the d' discriminability values, Pearson correlation analyses were performed between d', the number of recorded cars, the number of different areas where subjects had parked and the ratio between AM=PM / AM+PM values. The highest value obtained with d' was a significant correlation with the number of different areas [$r = -0.69$, $p<.001$]. This correlation value did not change very much, even when the number of recorded cars or the ratio estimations were partialled out, [$r = -0.63$]. These analyses strongly suggest that subjects performance, expressed in d' values, is mainly a negative function of the number of different parking locations.

CONCLUSION

The results of the last experiment revealed that long-term recency effects can be observed in a new naturalistic setting. Although the influence of both elapsed time and interpolated events could have affected recall performance, it was not possible to replicate Baddeley and Hitch (1977) result that the recency effect was largely dependent on interpolated events rather than elapsed time.

In fact, the rugby game study and the parking experiment involved two different real life situations. Rugby players played with a different team every week, thus each to-be-remembered memory event was different from the previous one. However, about half of the total number of subjects in the present experiment parked in a very few number of spots or in identical spots in AM and PM. When subjects were required to recall where they had parked, most subjects had access to more effective retrieval cues than the rugby players.

The results also indicated that recall performance for parking occasions was subject to progressive decline over a short period of two weeks, even when recall accuracy has been loosened from 74 locations (measure 1) to about 40 (measure 2), 12 (measure 3), or 0 (measure 4). In other words, recall for the most recent events was higher than for earlier ones. If this could be expected for the most stringent measures, it was with some surprise, that recency was observed in measure four.

Finally, this experiment showed that when the number

of recorded parking occasions is kept constant, another candidate to explain the recall impairment is the number of similar parking spots and similar parking in AM and PM. The highly negative correlation between d' prime values and the number of different parking occasions support the claim that parking very often in the same location is a powerful cue to retrieve the correct parking location later. The big gap in percent correct recall between the two groups in Figure 5.3 and 5.4 is a clear indication that the similar group had access to more effective retrieval cues.

EXPERIMENT 6

Although the results of the first experiment have shown that the observed forgetting could be the result, either of elapsed time or intervening events, the data did not allow us to reach a conclusion. One of the reasons might have been due to the fact that the experiment had to account for a great deal of variance among subjects.

Subjects differed according to the number of times they arrived, the number of similar or dissimilar parking occasions over the entire period and the similar or dissimilar parking in AM and PM. In addition to that, subjects came some mornings by car and left some time afterwards, either for testing outside the APU or for other business. It is likely that some of these subjects may have returned before 11.30 AM.

Therefore, it may not be a major surprise that no clear indication about the differential effects of elapsed time and interpolated events on recall had emerged. Moreover, we have tried to obtain evidence about the influence of the two previous variables on the grounds of the power of a statistical test, rather than on designing a neat and proper experiment to test such variables.

In order to design a proper experiment, it was decided to manipulate the length of the retention interval between the occurrence of the terminal event and the testing time, assuming that such manipulations could shed some lights on the effects of elapsed time and interpolated events.

Such an experiment does allow us to control the number of similar interpolated events, as expressed by the number of parking occasions in a similar environment, in this case at APU. In contrast, the experiment does not take into account the absolute number of parking occasions that will obviously take place everyday in other parts of Cambridge or elsewhere during the retention interval.

For this study, three retention intervals were chosen between the latest parking occasion and the recall test: two hours, one week and one month. The experiment was carried out on members of the APU subject panel.

APU has a subject panel with about one thousand subjects. On average each subject is invited to come to the APU for testing three or four times a year, although there are some variations according to the requirements of the experiments that are going on in the Unit. From this sample of subjects we do not know in advance how many will arrive by car, bus or bicycle, but whatever the number is, we decided to record the parking spot of those subjects who drove their cars to APU.

Two major trends in the results could be obtained: A decrement in recall performance for the last parking occasion at APU may could be dependent on the length of the retention interval. If this was the case, then the results could be accounted for by almost all major explanations of the long-term recency effect: trace strength theory, interference from parking elsewhere, and the temporal discriminability hypothesis. On the other hand, if no differences were

observed, then the trace decay hypothesis at least could be rejected.

METHOD

From December to March 1983 the parking locations and car registrations of 80 subjects who came by car to APU for testing were recorded. Forty eight came for group testing on one of three occasions and all the others came for individual testing. These subjects came at one of several times in the morning or the afternoon, but none came after dark (i.e., no later than 4.30 PM).

The times coincided with the working time of APU staff, so subjects had to choose an empty parking spot in the parking area, when they arrived. This fact allowed a certain degree of chance about the parking spot and prevented subjects parking in a favourite spot.

Due to the fact that there were no marks on the car park to confine each car to one parking spot, cars could be parked on a specific spot (e.g., 51) or two contiguous spots (e.g., 50/51). Thus the parking positions were recorded, as occurring in one or in two contiguous spots.

Subjects were 64 females and 16 males with ages in the 28-71 years range. The average age was between 40 and 44 years for all three groups, with S.D. between 8 and 11 years.

For the one week and one month groups, a letter with an appended plan of the APU parking area and a stamped addressed envelope was send to each subject six and 29 days

after each subject's latest visit to APU (*). Subjects were informed that we were interested in memory for everyday events and we would be extremely grateful if they were prepared to help us by trying to remember where they had parked their cars when they came to APU for testing.

Subjects were encouraged to guess if they were unsure and it was emphasized that locations were approximate, so if their cars were, for instance, between location 57 and 58, they should respond 57/58; If they had absolutely no idea where they had parked, they should respond with a dash.

Everybody, to whom the letters were sent, replied.

For the two hour group, subjects were tested at the end of one of three 2-hour sessions. Since a few subjects had come by bus or bicycle they were also required to read the letter and to write down "bus" or "bicycle". The purpose was to keep them busy for a while and to prevent them leaving the room and disturbing the other subjects.

The final number of subjects in two hour, one week and one month conditions was respectively 29, 26 and 25. The numbers were not matched, since the number of subjects in the group testing sessions, who would come by car, was not known in advance.

(*) A copy of the letter is presented in the Appendix.

RESULTS

Regardless of being correct or not, the parking spot was recorded, either according to one location or two contiguous locations and compared with the number of responses subjects gave with one or two locations.

Table 6.1 shows that, as the elapsed time between learning and recall increases, subjects produced more and more two location responses. A chi-square test performed between three groups and subject responses with one or two spots showed a highly significant effect [$X2(2) = 14.1$, $p<.001$].

Correct results were divided into three dependent variables, according to the same criteria followed in the previous experiment: accurate responses, correct responses plus or minus one location, and correct responses within the

Table 6.1

Total number of one or two locations recorded and responded, regardless of being correct or not.

	1 Location		2 Locations	
	Recorded	Response	Recorded	Response
2 Hours, n = 29	21	25	8	4
1 Week, n = 26	24	18	2	8
1 Month, n = 25 *	23	9	2	15

(*) One subject said he had no idea where he parked and his response was not included in Table 6.1.

same parking area. Percent correct recall for parking occasions as a function of retention interval and the criterion measure is shown in Table 6.2.

The results showed that percent recall did not differ across the retention interval selected. Correct responses for the most precise measure were about 72%, and for the criterion of correct plus or minus one location about 92 percent. If the criterion for correct responses is loosened by including all responses within the same area as correct, then there were only five wrong responses and four of them were directional confusions (*). Subjects have parked on one side of Chaucer Road (70-75) and responded with locations on the opposite side of the road (100-105).

Table 6.2

Percent correct recall for parking occasions as a function of the retention interval and the accuracy levels.

Retention Interval	Accurate Responses	Correct +/- one Location	Correct Within the Same Area
2 Hours, n = 29	72	93	93
1 Week, n = 26	73	92	96
1 Month, n = 25	72	92	92

(*) The other wrong response was from a subject in the "one month" group, who said he had no idea where he had parked.

Although percent correct recall did not seem to differ across the retention interval, it is noteable that subjects gave more two location responses as elapsed time increased. It seems likely that answers given with two adjacent locations meant that subjects felt less confident on recalling the parking location.

It might be argued that responses with two locations inflated percent recall for the one month group in the "accurate responses" measure. If this was so, then the value was adjusted, when percent recall for "plus or minus one location" responses was taken into account. But even so the percent correct recall for plus or minus one location was very much at the same level (92%) for all three conditions.

DISCUSSION

The similar and consistent pattern observed in these results can be discussed according to different interpretations:

1. Since the amount of forgetting was equivalent after the three different retention intervals, elapsed time was not responsible for the forgetting observed. Thus, the trace strength theory seems inadequate to account for the data.

2. Interference from intervening parking occasions elsewhere other than at APU did not play any relevant influence, otherwise the one month and one week group would have shown lower recall than the two hours group. Consequently, these results refuted a strong version of the interference theory.

3. A temporal discriminability hypothesis also seems to run into problems. If it is assumed that subjects are invited for testing at more or less regular intervals, then the interpresentation interval would have an equivalent value for each group. Since the retention interval was the independent variable manipulated and its values the denominator of the ratio in which the interpresentation interval was the numerator, then the values of this ratio would suggest that recall performance would decline as the retention interval increased. Yet the data did not support this hypothesis.

These results could be interpreted as a kind of von

Restorff effect. Either in the one week and in the one month condition, subjects would have certainly parked in different places and parking at APU was an isolated case, in an otherwise series of routine parking occasions. If this interpretation is valid, then the last parking occasion at the supermarket, church, hairdresser, cinema or today's parking at work should be as well recalled as when they parked at APU.

Why this is so? It could be argued that visiting the APU for testing and consequently parking there is a distinctive event in the routine of one's life, in the same way as the last visit to the Church, supermarket, or today's work. It is interesting to note from the APU staff parking experiment that Figure 5.1 shows that percent recall for that day's parking at work was 77%, 95%, 95% and 100% for each four measures taken. The present experiment produced very similar results.

Another interpretation would suggest that the last parking occasion at the APU was subject to similar response competition in equivalent amounts for all three groups. If the interference theory is adopted, then it could be argued that the last parking event was not subject to any retroactive interference in any group, and the effects of proactive interference from previous visits could have been already released or dissipated due to the interval length. In order to know how adequate this interpretation may be another experiment was carried out.

EXPERIMENT 7

The results of experiment five showed that the long-term recency effect observed could be due to either elapsed time or interpolated events. The results of experiment six indicated that both temporal decay and the number of absolute parking occasions occurring in different parking occasions in other environments during the retention interval could be discarded as far as the recall of an isolated event was concerned. Thus far, the results of these experiments may suggest that one of the major factors of forgetting in this situation is interference from parking in similar settings and not any other kind of intervening event.

Similarly, proactive interference from a previous parking occasion at APU seems an unlikely explanation, since this too would predict an increase in forgetting over time. In order to explore this question further, the next experiment investigated how performance might be affected if two visits to APU occured close in time.

This experiment was designed to test whether the forgetting observed in memory for parking occasions over a month period could be due to proactive (PI) or retroactive (RI) interference. Two groups from the APU subject panel, who came twice for testing within a two weeks period, were asked one month after the first visit (RI), or the second visit (PI), to locate the parking spot in a map for each of the two visits.

In the previous experiment it was observed that after a month interval, 92% of the subjects were able to correctly recall the approximate location, where they had parked. If subjects were required to come twice for testing within a two weeks interval it was expected that performance would be more impaired than in the previous experiment. In addition, the experiment was designed to test if recall performance was mainly affected by a second parking occasion, that preceded or followed the target visit.

METHOD

Members of the APU subject panel were invited to come to the APU for two group testing sessions separated by about two weeks. At the beginning or end of each session subjects were asked, while they were filling in the payment receipt, if they had come by car, bus or bicycle. Then they were required to write down on the back of their receipts, "bus", "bicycle" or "car and its registration". To those few subjects who look rather curious, given this task, it was said that some people do not remember the correct registration of their cars and we would like to check how many they were.

All the subjects in these sessions, who came by car, were invited by post or telephone to return again about two weeks later for a testing session of one or two hours, and most of them agreed.

Twenty eight male and 35 female subjects in the 25-71 years age range were tested. Almost all of these subjects

came for evening sessions at the end of April and during May and June 1983. The only difference between subjects in experiments six and seven concerned their parking choice. When subjects in this experiment arrived at the APU for testing most APU staff had already left and hence there was more room for choosing an empty parking spot.

In the PI group, the second visit was considered the target and a letter was sent to subjects one month after the second visit. In the RI group, the first of the two visits was the target and a letter was also sent one month later. In the mailed letter it was explained that we were interested in memory for parking occasions and we would be extremely grateful if they would be prepared to answer two questions inside two separate envelopes.

They were requested to open envelope one first. This contained a question about the target inside. Only after answering the question in envelope one, was the subject to go to envelope two, and answer the second question. This question concerned the first visit in the PI group and the second visit in the RI group. responding was aided by the map with numbered parking places. The phrasing of the questions was identical to the second experiment (*). Subjects were required to reply using an enclosed stamped addressed envelope.

All 63 subjects returned their completed questionaires.

(*) A copy of the letters posted to subjects is presented in the Appendix.

RESULTS

The total number of one and two location responses produced in the PI and RI groups for the target location, regardless of correctness is shown in Table 7.1.

Subjects in each group responded with one or two locations in approximate numbers. A chi-square test performed between responses with one or two locations and two interference groups showed no differences, [$X2(1) = .50$, $p = .52$].

Percent correct recall of PI and RI groups as a function of criterion measure is presented in Table 7.2. In order to facilitate the comparison between recall performance for one and two visits, percent recall from the previous experiment for the "one month" group was also presented.

Table 7.1

Total number of one and two locations recorded and responded in PI and RI groups for the target location.

	Recorded		Responded	
	PI	RI	PI	RI
1 Location	27	29	19	18
2 Locations	3	4	11	15
Total	30	33	30	33

Table 7.2 shows that percent correct recall for accurate locations observed in the previous experiment was at least 25% higher than in the present experiment, where the target location was preceded or followed some days later by another parking event in the same setting.

A chi-square analysis performed on data presented in Table 7.2 for "correct accurate responses" in each of the three groups produced a significant value, [X2(2) = 6.42, p<.05]. The chi-square performed again for "correct plus or minus one location" yielded another significant value, [X2(2) = 7.24, p<.05]. However, the differences between the three groups were reduced to non-significant levels when the chi-square test was performed for "correct recall within the same area" [X2(1) = 4.12, p = 0.13].

Table 7.2

Percent recall of parking occasions for the target visit, as a function of measure accuracy and interference groups.

Groups	Measures		
	Accurate Responses	Correct +/- One Location	Correct Within the Same Area
PI, n = 30	47	70	73
RI, n = 33	39	60	88
Experiment 6 n = 25	72	92	92

The results of Table 7.2 were also analysed in order to see if recall performance of the two interference groups was significantly different from each other. The chi-square values obtained were for "accurate responses" [X2(1) = 0.34], "correct plus or minus one location", [X2(1) = 0.61], "correct within the same area, [X2(1) = 2.16, p= 0.14]. These analysis indicated that recall performance did not differ significantly in the PI and RI groups.

It can be argued, however, that the PI and RI groups may have differed in other ways than those we stated in the procedure. Percent correct recall may have been affected by parking in an identical or similar spot when subjects came for the second time. If there were more subjects in one group with more similar parking spots than in the other group this variable could have a large effect on the results.

We therefore recorded the total number of subjects in the two interference groups who parked twice in the same location. The data are shown in Table 7.3. Fortunately the total number of subjects who parked in a similar or dissimilar location was almost equivalent.

All subjects who parked in the "same location", in the "plus or minus one location", and "within the same area" were then excluded progressively from the analysis; the results are presented in Table 7.4. The data in this Table show that percent correct recall decreases in the PI group as the number of subjects who parked similarly twice are taken out of the analysis. The decrement is between 16% and 23% and it is almost absent in the RI group.

Table 7.3

Total number of subjects in the two interference groups, who parked twice in same or different locations.

Groups	Same Location	+/- One Location	Same Area	Different Area
PI, n = 30	6	5	3	16
RI, n = 33	5	4	6	18

Table 7.4

Percent correct recall in PI and RI groups as a function of three types of measure accuracy, after having excluded the responses from the subjects, who parked twice in the same location (second row); twice in plus or minus one location (third); twice in the same area (fourth row).

N	Accurate Responses	Correct +/- One Location	Correct Within the Same Area	Binonimal test for Previous Column
PI				
30	47	70	73	p<.01
24	42	63	67	p=.07
19	37	53	58	N.S.
16	31	44	50	N.S.
RI				
33	39	60	88	p<.001
28	36	57	86	p<.001
24	42	63	84	p<.001
18	39	67	78	p<.01

Categorizing as correct responses the cumulative correct responses for the same area (column 4, in Table 7.4) and all the remaining responses as errors, a binonimal distribution analysis was carried out. The binonimal test indicates whether the number of correct responses is significantly different from chance level. The values of the binonimal test showed that the number of correct responses for the RI group was always above the chance level at $p<.01$, for each number of subjects regarded.

This analysis seems to suggest that, when the variance related to the presence of similar parking occasions in both visits is controlled, recall performance in the PI group seems to be more affected than in the RI group. However, when a chi-square analysis was performed between the PI and the RI groups in the less accurate of all three measures where the largest differences were observed, and after excluding all similar parking occasions, the value obtained was not significant, [$X2(1) = 2.86$, $p = 0.09$]. These and previous analyses indicate that PI and RI groups do not differ significantly from each other in any variable.

Second Visit Data

The data of the second visit are shown in Table 7.5, as a function of criterion measure and type of interference. The data are also broken down according to the number of similar parking occasions. The differences between the two groups were highly significant for each type of measure.

Table 7.5

Percent correct recall as a function of measure accuracy and type of interference for the second visit. The data was broken down according to the number of similar parking occasions in the two visits.

PI (6 weeks)

N	Accurate Responses	Correct +/- One Location	Correct Within the Same Area
30	20	43	67
24	17	33	58
19	21	32	53
16	25	38	44

RI (2 weeks)

33	61	85	94
28	54	82	93
24	50	79	92
18	50	78	89

A chi-square analysis performed on the total number of correct responses and the consequent number of errors on the measure "correct within the same area", between PI (n = 30) and RI (n = 33) showed a significant value, [X2(1) = 7.58, p<.01]. On the more strict measures the chi-square values were of course highly significant.

The results of the RI group, which represented the most recent visit, were in the same range as the results of the previous experiment for the "1 month" retention interval group. The chi-square analysis performed on both groups in the "accurate recall" measure was very far from being significant, [X2(1) = 0.82, p=.37]. Therefore, it is reasonable to assume that these results replicated those of experiment six.

The data in Table 7.5 seem to indicate that the similarity of parking occasions did not greatly affect retention after either a 2-week (RI), or a 6-week (PI group) period.

Analysis of Errors

In general, the data of the present experiment did not reveal any significant difference between PI and RI groups, as far as the target visit was concerned. Therefore, it was decided to carry out an analysis of errors to see if it was possible to shed further light on the differences between the

two interference groups.

Let us consider firstly the errors for the target visit (one month) in the PI and RI group. In the PI group eight subjects out of 30 (27%) responded to the target visit with locations which were correct if given to the second visit (six weeks). From these proactive intrusion errors, five would be considered "accurate responses" and three "correct within an area".

In the RI group, only four subjects (12%) responded with a parking spot from a different area. However, only one response was a retroactive intrusion from the second visit (two weeks). Two responses were adjacent parking spots (at 34 and 40 locations), and the fourth error was from a subject, who parked in the Road (82) and responded with a location inside the private parking area (53/54).

As far as the second visit is concerned, in the PI group, ten subjects (33%) responded with locations from a different area. Seven responses were retroactive intrusions from the most recent visit, and five would be considered "accurate responses" and "correct within the same area". The other two were intrusions from adjacent areas from the most recent visit. The remaining three errors, two were from adjacent areas related to the second visit, and one error did not reveal any clear link.

In the RI group, there were only two subjects (6%) who responded with locations from different areas. These two errors did not indicate any connection with any of the two

visits.

In summary, subjects in the PI group, who came six and four weeks earlier, produced eight forward and seven backward intrusions. In contrast, subjects in the RI group, who came four and two weeks earlier, only produced one backward intrusion. The error data seem to suggest that the farther away a lag of two weeks is from testing the more forgetting will occur.

GENERAL DISCUSSION

The principal findings of the present study can be summarized as follows:

1. Long-term recency effects were observed with a new task on memory for car parking occasions. The recall function seemed to be dependent on both elapsed time and interpolated events.

2. In experiment six evidence was given that the retention interval was not responsible for the forgetting observed in an isolated car parking occasion at APU. Furthermore, recall performance was independent of the number of car parking occasions, which should have occurred in several other places during the retention interval.

3. The results of the experiment seven showed that forgetting was mainly a function of a second parking occasion that occurred in the same environment.

Traditionally, several explanations have accounted for the recency effect:

The trace strength hypothesis claims that forgetting is a function of the total time the trace remains in store. However, this explanation was ruled out by the results of Experiment six.

Interference theory predicted that recall performance would be affected by a second visit occurring in the same environment. This was confirmed. Nevertheless, the forgetting observed in the PI group for the four and six week

visits was mainly due to proactive and retroactive intrusions. In contrast, the forgetting observed in the RI group for four and two weeks was largely independent of each other intrusions. However, the error data does not mean that intrusions were the cause of forgetting. It only means that the farther apart from the present a two-week lag occurred, the more intrusions were given.

The temporal discrimination hypothesis says that the farther apart two events are, the better they will be recalled. This interpretation claims that recall performance is related to the ratio between the interpresentation interval and the retention interval. In addition, the ratio value seems to be highly correlated with the recency effect expressed in slope values. Glenberg et al. (1983) found a correlation value of 0.93 between ratio and slopes.

In a strict sense, the temporal discrimination hypothesis has some difficulties to account for the data. In experiment seven, the value of the interpresentation interval was two weeks for both PI and RI groups, and the retention interval was four and two weeks respectively. Thus, the ratio was smaller for PI than RI group. Taking into account the highly correlation value between ratio and slopes, it is expected that the slopes in experiment seven are smaller for PI than RI groups. However, the data showed that the slope values were smaller for the RI group (0.22) than for the PI group (0.27) for accurate recall responses. For "correct plus or minus one spot" the slopes were respectively 0.25 and 0.27 for RI and PI groups.

Although the ratio rule values have not predicted the trend for the PI and RI data, it is fair to say that the slopes obtained were not far away from the values predicted. In this case the slopes could be accounted for by the remaining variance involved in the 0.93 correlation coefficient between ratio and slopes.

In a broad sense and taken especially into account the type of intrusions observed, the temporal discriminability hypothesis can account for the data obtained. In Experiment six, the value of the interpresentation interval was so large (i.e., about 110 days assuming that subjects come three or four times a year) that the values of the retention interval (e.g., 6 and 30 days) may have been insensitive to the power of the ratio rule. When the interpresentation interval was decreased to two weeks in experiment seven, and kept constant between PI and RI groups (two weeks), the results showed that the farther away two events occurred, the more difficult it would be for subjects to discriminate between them. Yet, the results showed that subjects still have the information about where they parked, but they were unable to allocate such information to the appropriate event.

Finally, laboratory studies have already demonstrated that the farther away two events occur, the more difficult it is to discriminate between them. Such studies were reported in chapter three, and the best well-known of them was one by Yntema and Trask (1963). Experiment seven demonstrated that the lag effect occurs in a naturalistic setting and may have been responsible for the recall performance obtained.

General Conclusion

At this stage, I would like to briefly point out what I think are the major contributions of this dissertation.

In chapter one to five a detailed discussion of the recency effect obtained in several short- and long-term memory tasks and the interpretations given was made. A retrieval process based on temporal order cues was regarded as better suited to account for the recency effect obtained in several memory tasks than alternative explanations, such as the trace strength hypothesis, the interference theory or the output from short-term store. In addition, it was claimed that a retrieval interpretation could also be extended to the primacy effect.

The primacy effect has been largely regarded in the literature as a storage effect based on rehearsal activities. However, recent published data on serial position effects and obtained with infrahumans, preverbal infants and in incidental memory tasks suggested that the traditional interpretation of the primacy effect is not entirely adequate.

Therefore, a common interpretation of primacy and recency was put forward. It was claimed that primacy and recency could be an automatic process based on the distinctiveness or the temporal discontinuity of the ends-of-a-series of items. Stressing that primacy and recency are an automatic process does not rule out the contribution of other processes, such as the effects of rehearsal on primacy,

or the effects of output order on recency. These and other processes also contribute to strengthen the size of serial position effects, which otherwise will be present.

Serial position effects and the recency effect in particular were the focus of the experimental work carried out in this dissertation. The first Experiment was an attempt to reveal the locus of age deficits in the serial position curve. The results indicated that ageing deficits were especially located at primacy and recency, when a more demanding memory task was used. In addition, the data suggested that the impairment observed in the older group might have been due to both output order and to subjects' difficulty to process contextual cues associated with the primacy and recency segments.

Chapter seven examined two different predictions about the recency effect in a list recency task in three experiments. On the one hand, if the Bjork and Whitten's (1974) boundary conditions were adopted, then recency effects would be obtained in a list recency task, even with highly categorized verbal materials. On the other hand, if Tulving and Psotka's (1971) claim was adopted, especially the claim that the list recency effect was the result of higher order units being unavailable at testing, then list recency would be obtained with highly categorized verbal materials. The latter prediction is based upon the assumption that recency is a low level retrieval strategy used in the absence of a semantic cue. The results showed a list recency effect with highly categorized verbal materials, only when the degree of learning

of all word lists was roughly similar. Therefore, the finding that list recency is obtained with highly categorized materials adds to earlier research and suggests that Tulving and Psotka's (1971) interpretation requires some modifications.

Chapter eight explored the presence of recency effects on memory for car parking and investigated the effects of elapsed time and interpolated events for this everyday situation. The results of Experiment five produced a clear-cut long-term recency effect, thus increasing the data pool of naturalistic studies on this topic. Experiment six indicated that elapsed time had no effect on memory for car parking, even when a month period has elapsed. In my view, this was the major finding of this dissertation. Finally, Experiment seven showed that a classical theory of interference could not fully account for the equivalent results obtained with proactive and retroactive interference groups. Instead, an explanation based upon temporal discriminability seemed better suited than other alternatives to account for the data obtained.

REFERENCES

Allan, L.G. (1979). The perception of time. Perception & Psychophysics, 26, 340-354.

Anderson, J.R., & Bower, G.H. (1972). Recognition and retrieval processes in free recall. Psychological Review, 79, 97-123.

Arenberg, D. (1976). The effects of input condition on free recall in young and old subjects. Journal of Gerontology, 31, 551-555.

Atkinson, R.C., & Shiffrin, R.M. (1968). Human memory: A proposed system and its control processes. In K.W. Spence & J.T. Spence (Eds.), The psychology of learning and motivation: Advances in research and theory (Vol. 2, pp. 89-195). New York: Academic Press.

Baddeley, A.D. (1966a). The influence of acoustic and semantic similarity on long-term memory for word sequences. Quarterly Journal of Experimental Psychology, 18, 302-309.

Baddeley, A.D. (1966b). Short-term memory for word sequences as a function of acoustic, semantic and formal similarity. Quarterly Journal of Experimental Psychology, 18, 362-365.

Baddeley, A.D. (1970). Estimating the short-term component in free recall. British Journal of Psychology, 61, 13-15.

Baddeley, A.D. (1976). The Psychology of memory. New York: Basic Books.

Baddeley, A.D. (1981). The cognitive psychology of everyday life. British Journal of Psychology, 72, 257-269.

Baddeley, A.D. (1982). Domains of recollection. Psychological Review, 89, 708-729.

Baddeley, A.D. (1983). Working memory. In D.E. Broadbent (Ed.), Functional aspects of human memory (pp. 73-86). London: The royal society.

Baddeley, A.D., & Hitch, G.J. (1974). Working memory. In G.H. Bower (Ed.), The psychology of learning and motivation: Advances in research and theory (Vol. 8, pp. 47-89). New York: Academic Press.

Baddeley, A.D., & Hitch, G.J. (1977). Recency re-examined. In S. Dornic (Ed.), Attention and performance (Vol. 6,

pp. 647-667). Hillsdale, NJ: Erlbaum.

Baddeley, A.D., Lewis, V., & Nimmo-Smith, I. (1978). When did you last ...? In M.M. Gruneberg, P.E. Morris, & Sykes, R.N. (Eds.), Practical aspects of memory (pp. 77-83) London: Academic Press.

Baddeley, A.D., & Scott, D. (1971). Short-term forgetting in the absence of proactive inhibition. Quarterly Journal of Experimental Psychology, 23, 275-283.

Baddeley, A.D., & Wilkins, A. (1984). Taking memory out of the laboratory. In J.E. Harris & P.E. Morris (Eds.), Everyday memory, actions and absent-mindedness (pp. 1-17). London: Academic Press.

Bahrick, H.P., Bahrick, P.O., & Wittlinger, R.P. (1975). Fifty years of memory for names and faces: a cross sectional approach. Journal of Experimental Psychology : General, 104, 54-75.

Bahrick, H.P., Karis, D. (1982). Long-term ecological memory. In J.L. Puff (Ed.), Handbook of research methods in human memory and cognition (pp. 427-465). New York: Academic Press.

Battig, W.F., & Montague, W.E. (1969). Category norms for verbal items in 56 categories: A replication and extension of the Connecticut category norms. Journal of Experimental Psychology Monographs, 80 (3, Pt. 2).

Bekerian, D.A. & Baddeley, A.D. (1980). Saturation advertising and the repetition effect. Journal of Verbal Learning and Verbal behavior, 19, 17-25.

Bernbach, H.A. (1975). Rate of presentation in free recall: A problem for two-stage theories. Journal of Experimental Psychology: Human Learning and Memory, 104, 18-32.

Birren, J.E., & Renner, V.J. (1977). Research on the psychology of aging: Principles and experimentation. In J.E. Birren & K.W. Schaie (Eds.), Handbook of the psychology of aging (pp. 3-38). New York: Van Nostrand Reinhold Company.

Bjork, R.A., & Whitten, W.B.,II. (1974). Recency-sensitive retrieval processes in long-term free recall. Cognitive Psychology, 6, 173-189.

Bower, G.H. (1967). A multicomponent theory of the memory trace. In K.W. Spence & J.T. Spence (Eds.), The psychology of learning and motivation: Advances in research and theory (Vol. 1, pp. 299-325). New York: Academic Press.

Bower, G.H., & Reitman, J.S. (1972). Mnemonic elaboration in multilist learning. Journal of Verbal Learning and Verbal Behavior, 11, 478-485.

Brener, R. (1940). An experimental investigation of memory span. Journal of Experimental Psychology, 26, 467-482.

Broadbent, D.E. (1958). Perception and communication. London: Pergamon Press.

Brodie, D.A., & Murdock, B.B., Jr. (1977). Effect of presentation time on nominal and functional serial-position curves of free recall. Journal of Verbal Learning and Verbal Behavior, 16, 185-200.

Brodie, D.A., & Prytulak, L.S. (1975). Free recall curves: Nothing but rehearsing some items more or recalling them sooner? Journal of Verbal Learning And Verbal Behavior, 14, 549-563.

Brown, J. (1958). Some tests of the decay theory of immediate memory. Quarterly Journal of Experimental Psychology, 10, 12-21.

Brown, R. & Kulik, J. (1977) Flashbulb memories. Cognition, 5, 73-99.

Bruce, D., & Crowley, J.J. (1970). Acoustic similarity effects on retrieval from secondary memory. Journal of Verbal Learning and Verbal Behavior, 9, 190-196.

Buchanan, J.P., Gill, T.V., Braggio, J.T. (1981). Serial position and clustering effects in a chimpanzee's "free recall". Memory & Cognition, 9, 651-660.

Burke, D.M., & Light, L.L. (1981). Memory and aging: The role of retrieval processes. Psychological Bulletin, 90, 513-546.

Byrne, B. & Arnold, L. (1981). Dissociation of the recency effect and immediate memory span: Evidence from beginning readers. British Journal of Psychology, 72, 371-376.

Carey, S.T. (1973). Delayed recognition testing, incidental learning, and proactive inhibition release. Journal of Experimental Psychology, 100, 361-367.

Cermak, L.S. (1970). Decay of interference as a function of the intertrial interval in short-term memory, Journal of Experimental Psychology, 84, 499-501.

Cohen, R.L. & Sandberg, T. (1977). Relation between intelligence and short-term memory. Cognitive Psychology, 9, 534-554.

Cole, M., Frankel, F., & Sharp, D. (1971). Development of free recall learning in children. Developmental Psychology, 4, 109-123.

Conrad, R. (1957). Decay theory of immediate memory. Nature, 831-832.

Conrad, R. (1964). Acoustic confusions in immediate memory. British Journal of Psychology, 55, 75-84.

Conrad, R. (1965). Order errors in immediate recall of sequences. Journal of Verbal Learning and Verbal Behavior, 4, 161-169.

Conrad, R., & Hille, B.A. (1958). The decay theory of immediate memory and paced recall. Canadian Journal of Psychology, 12, 1-6.

Corman, C.N., & Wickens, D.D. (1968). Retroactive inhibition in short-term memory. Journal of Verbal Learning and Verbal Behavior, 7, 16-19.

Cornell, E.H., Bergstrom, L.I. (1983). Serial-position effects in infants' recognition memory. Memory & Cognition, 11, 494-499.

Craik, F.I.M. (1968). Two components in free recall. Journal of Verbal Learning and Verbal Behavior, 7, 996-1004.

Craik, F.I.M. (1970). The fate of primary memory items in free recall. Journal of Verbal Learning and Verbal Behavior, 9, 143-148.

Craik, F.I.M. (1977). Age differences in human memory. In J.E. Birren & K.W. Schaie (Eds.), Handbook of psychology of aging (pp. 384-420). New York: Van Nostrand Reinhold.

Craik, F.I.M., & Levy, B.A. (1970). Semantic and acoustic information in primary memory. Journal of Experimental Psychology, 86, 77-82.

Craik, F.I.M., & Lockhart, R.S. (1972). Levels of processing: A framework for memory research. Journal of Verbal Learning and Verbal Behavior, 11, 671-684.

Craik, F.I.M. & Rabinowitz, J.C. (1984). Age differences in the acquisition and use of verbal information: A tutorial review. In H. Bouma & D.G. Bouwhuis (Eds.), Attention and performance X: Control of language processes (pp. 471-499). Hillsdale, NJ: Erlbaum.

Craik, F.I.M., & Simon, E. (1980). Age differences in memory: The roles of attention and depth of processing. In L.W. Poon, J.L. Fozard, L.S. Cermak, D. Arenberg,

& L.W. Thompson (Eds.), New directions in memory and aging: Proceedings of the George Talland memorial conference (pp. 95-112). Hillsdale, NJ: Erlbaum.

Craik, F.I.M., & Tulving, E. (1975). Depth of processing and the retention of words in episodic memory. Journal of Experimental Psychology: General, 104, 268-294.

Craik, F.I.M., & Watkins, M.J. (1973). The role of rehearsal in short-term memory. Journal of Verbal Learning and Verbal Behavior, 12, 599-607.

Crowder, R.G. (1976). Principles in learning and memory. Hillsdale, NJ: Erlbaum.

Crowder, R.G. (1979). Similarity and order in memory. In G.H. Bower (Ed.), The psychology of learning and motivation: Advances in research and theory (Vol. 13, pp. 319-353). New York: Academic Press.

Crovitz, H.F., & Quina-Holland, K. (1976). Proportion of episodic memories from early childhood by years of age. Bulletin of the Psychonomic Society, 7, 61-62.

Crovitz, H.F., & Schiffman, H. (1974). Frequency of episodic memories as a function of their age Bulletin of the Psychonomic Society, 4, 517-518.

Dalezman, J.J. (1976). Effects of output order on immediate, delayed, and final recall performance. Journal of Experimental Psychology: Human Learning and Memory, 2, 597-608.

Dallett, K.M. (1963). Practice effects in free and ordered recall. Journal of Experimental Psychology, 66, 65-71.

Darley, D.F., & Murdoch, B.B., Jr. (1971). Effects of prior free recall testing on final recall and recognition, Journal of Experimental Psychology, 93, 66-73.

Deese, J., & Kaufman, R.A. (1957). Serial effects in recall of unorganized and sequentially organized verbal material. Journal of Experimental Psychology, 54, 180-187.

Dillon, R.F., & Reid, L.S. (1969). Short-term memory as a function of information processing during the retention interval. Journal of Experimental Psychology, 81, 261-269.

Donaldson, W.A. (1971). Output effects in multi-trial free recall, Journal of Verbal Learning and Verbal Behavior, 10, 577-585.

Dudycha, G.J. & Dudycha, M.M. (1941). Childhood memories: A review of the literature. Psychological Bulletin, 38,

668-682.

Ebenholtz, S.M. (1972). Serial learning and dimensional organization. In G.H. Bower (Ed.), The psychology of learning and motivation: Advances in research and theory (Vol. 5, pp. 267-314). New York: Academic Press.

Ebbinghaus, H. (1885). Uber das gedachtnis. Duncker, Leipzig. (Translated by H. Ruger and C.E. Bussenius (1964)) Memory: A contribution to Experimental Psychology. New York: Dover Publications.

Eich, J.E. (1980). The cue-dependent nature of state dependent retrieval. Memory & Cognition, 8, 157-173.

Eysenck, M.W. (1974). Age differences in incidental learning. Developmental Psychology, 10, 936-941.

Estes, W.K., & DaPolito, F. (1967). Independent variation of information storage and retrieval processes in paired-associated learning, Journal of Experimental Psychology, 75, 18-26.

Fagan III, J.F. (1972). Rehearsal and free recall in children of superior and average intelligence. Psychonomic Science, 28, 352-354.

Fischler I., Rundus, D., & Atkinson, R.C. (1970). Effects of overt rehearsal procedures on free recall. Psychonomic Science, 19, 249-250.

Fozard, J.C. (1970). Apparent recency of unrelated pictures and nouns presented in the same sequence. Journal of Experimental Psychology, 86, 137-143.

Franklin, H.C., & Holding, D.H. (1977). Personal memories at different ages. Quarterly Journal of Experimental Psychology, 29, 527-532.

Gardiner, J.M. (1983). On recency and echoic memory. In D.E. Broadbent (Ed.), Functional aspects of human memory (pp. 29-44). London: The royal society.

Gardiner, J.M., Craik, F.I.M., & Birtwistle, J. (1972). Retrieval cues and release from proactive inhibition. Journal of Verbal Learning and Verbal Behavior, 11, 778-783.

Gardiner, J.M., & Gregg, V.H. (1979). When auditory memory is not overwritten. Journal of Verbal Learning and Verbal Behavior, 18, 705-719.

Geiselman, R.E., & Bjork, R.A. (1980). Primary versus secondary rehearsal in imagined voices: Differential effects on recognition. Cognitive Psychology, 12, 188-205.

Gianutsos, R. (1972). Free recall of grouped words. Journal of Experimental Psychology, 95, 419-428.

Gilhooly, K.J., & Logie, R.H. (1980). Age-of-acquisition, imagery, concreteness, familiarity and ambiguity measures for 1,944 words. Behavior Research Methods & Instrumentation, 12, 395-427.

Glanzer, M. (1976). Intonation grouping and related words in free recall. Journal of Verbal Learning and Verbal Behavior, 15, 85-92.

Glanzer, M. (1982). Short-term memory. In C.R. Puff (Ed.), Handbook of research methods in human memory and cognition (pp. 63-98). New York: Academic Press.

Glanzer, M., & Cunitz, A.R. (1966). Two storage mechanisms in free recall. Journal of Verbal Learning and Verbal Behavior, 5, 351-360.

Glanzer, M., & Koppenaal, L. (1977). The effect of encoding tasks on free recall: Stages and levels. Journal of Verbal Learning and Verbal Behavior, 16, 21-28.

Glanzer, M., Koppenaal, L., & Nelson, R. (1972). Effects of relations between words on short-term storage and long-term storage. Journal of Verbal Learning and Verbal Behavior, 11, 403-416.

Glanzer, M., & Meinzer, A. (1967). The effects of intralist activity on free recall. Journal of Verbal Learning and Verbal Behavior, 6, 928-935.

Glanzer, M., & Razel, M. (1974). The size of the unit in short-term storage. Journal of Verbal Learning and Verbal Behavior, 13, 114-131.

Glenberg, A.M. (1984). A retrieval account of the long-term modality effect. Journal of Experimental Psychology: Learning, Memory, and Cognition, 10, 16-31.

Glenberg, A.M., Bradley, M.M., Kraus, T.A., & Renzaglia, G.J. (1983). Studies of the long-term recency effect: Support for a contextually guided retrieval hypothesis. Journal of Experimental Psychology: Learning, Memory and Cognition, 9, 231-255.

Glenberg, A.M., Bradley, M.M., Stevenson, J.A., Kraus, T.A., Tkachuk, M.J., Gretz, A.L., Fish, J.H., & Turpin B.W. (1980). A two-process account of long-term serial position effects. Journal of Experimental Psychology: Human Learning and Memory, 6, 355-369.

Glenberg, A.M., & Kraus, T.A. (1981). Long-term recency is not found on a recognition test. Journal of Experimental Psychology: Human Learning and Memory, 7, 475-479.

Godden, D.R., & Baddeley, A.D. (1975). Context-dependent memory in two natural environments: On land and underwater. British Journal of Psychology, 66, 325-332.

Goodwin, C.J. (1976). Changes in primacy and recency with practice in single-trial free recall. Journal of Verbal Learning and Verbal Behavior, 15, 119-132.

Gorfein, D.S. (1970). Effects of intralist activity on free recall performance. Psychonomic Science, 20, 331-332.

Gorfein, D.S., & Jacobson, D.E. (1973). Memory search in a Brown-Peterson short-term memory paradigm. Journal of Experimental Psychology, 99, 82-87.

Greene, R.L. & Crowder, R.G. (1984). Effects of semantic similarity on long-term recency. American Journal of Psychology, 97, 441-449.

Gruneberg, M.M., Morris, P.E., & Sykes, R.N. (1978) Practical aspects of memory. London: Academic Press.

Hasher, L. & Zacks, R.T. (1979). Automatic and effortful processes in memory. Journal of Experimental Psychology: General, 108, 356-388

Hebb, D.O. (1949). The organization of behavior. New York: Wiley.

Hinrichs, J.V. (1970). A two-process memory strength theory for judgment of recency. Psychological Review, 77, 223-233.

Hinrichs, J.V., & Buschke, H. (1968). Judgment of recency under steady-state conditions. Journal of Experimental Psychology, 78, 574-579.

Hintzman, D.L., & Block, R.A. (1971). Repetition and memory: Evidence for a multiple-trace hypothesis. Journal of Experimental Psychology, 88, 297-306.

Hintzman, D.L., Block, R.A., & Summers, J.J. (1973). Contextual associations and memory for serial position. Journal of Experimental Psychology, 97, 220-229.

Hintzman, D.L., Summers, J.J., & Block, R.A. (1975). Spacing judgments as an index of study-phase retrieval. Journal of Experimental Psychology: Human Learning and Memory, 104, 31-40.

Hitch, G.J. & Halliday, M.S. (1983). Working memory in children. In D.E. Broadbent (Ed.), Functional aspects of human memory (pp. 87-101). London: The royal society.

Horowitz, L.M. (1961). Free recall and ordering of trigrams.

Journal of Experimental Psychology, 62, 51-57.

Hultsch, D.F. (1974). Learning to learn in adulthood. Journal of Gerontology, 29, 302-308.

Huttenlocher, J. & Burke, D. (1976). Why does memory span increase with age? Cognitive Psychology, 8, 1-31.

Hyde, T.S., & Jenkins, J.J. (1969). Differential effects of incidental tasks on the organization of recall of a list of highly associated words. Journal of Experimental Psychology, 82, 472-481.

Kausler, D.H. (1982). Experimental psychology and human aging. New York: John Wiley.

Kausler, D.H., Puckett, J.M. (1981). Adult age differences in memory for sex of voice. Journal of Gerontolongy, 36, 44-50.

Katz, L. (1968). The limited capacity hypothesis: Effects of sequence length and instructions in free recall. Journal of Verbal Learning and Verbal Behavior, 7, 942-944.

Keppel, G., & Mallory, W.A. (1969). Presentation rate and instructions to guess in free recall. Journal of Experimental Psychology, 79, 269-275.

Keppel, G. & Underwood, B. J. (1962). Proactive interference in short-term retention of single items. Journal of Verbal Learning and Verbal Behavior, 1, 153-161.

Kincaid, J.P., & Wickens, D.D. (1970). Temporal gradient of release from proactive inhibition, Journal of Experimental Psychology, 86, 313-316.

Kintsch, W. (1970). Models for free recall and recognition. In D.A. Norman (Ed.), Models of human memory (pp. 331-373). New York: Academic Press.

Kintsch, W., & Buschke, H. (1969). Homophones and synonyms in short-term memory. Journal of Experimental Psychology, 80, 403-407.

Koriat, A. & Fischhoff B. (1974). What day is today? An inquiry into the process of time orientation. Memory & Cognition, 2, 201-205.

Leich, K.L. (1968). Differential rehearsal and primacy effects. Journal of Verbal Learning and Verbal Behavior, 7, 1115-1117.

Levy, B.A. (1971). Role of articulation in auditory and visual long-term memory. Journal of Verbal Learning and

Verbal Behavior, 10, 123-132.

Lewis-Smith, M.Q. (1975). Short-term memory as a processing deficit. American Journal of Psychology, 88, 605-626.

Lindsay, P.L., & Norman, D.A. (1977). Human information processing: An introduction to psychology, (2nd ed.). New York: Academic Press.

Linton, M. (1982). Transformations of memory in everyday life. In U. Neisser (Ed.), Memory observed: Remembering in natural contexts. San Francisco: W. H. Freeman and company.

Lockhart, R.S. (1969). Recency discrimination predicted from absolute lag judgments. Perception & Psychophysics, 6, 42-44.

Loess, H., & Waugh, W.C. (1967). Short-term memory and intertrial interval. Journal of Verbal Learning and Verbal Behavior, 6, 455-460.

Marshall, P.H., & Werder, P.R. (1972). The effects of elimination of rehearsal on primacy and recency. Journal of Verbal Learning and Verbal Behavior, 11, 649-653.

Martin, E. (1971). Verbal learning and independent retrieval phenomenon. Psychological Review, 78, 314-332.

Maskarinec, A.S., & Brown. S.C. (1974). Positive and negative recency effects in free recall learning. Journal of Verbal Learning and Verbal Behavior, 16, 328-334.

McCormack, P.D. (1979). Autobiographical memory in the aged. Canadian Journal of Psychology, 33, 118-124.

Melton, A.W. (1963). Implications of short-term memory for a general theory of memory. Journal of Verbal Learning and Verbal Behavior, 2, 1-21.

Melton, A.W., & Irwin, J.M. (1940). The influence of degree of interpolated learning on retroactive inhibition and the overt transfer of specific responses. American Journal of Psychology, 53, 173-203.

Meunier, G.F., Stanners, R.F., & Meunier, J.A. (1971). Pronounceability, rehearsal time, and the primacy effect of free recall. Journal of Experimental Psychology, 88, 123-127.

Michon, J.A. & Jackson, J.L. (1984). Attentional effort and cognitive strategies in the processing of temporal information. In J. Gibbon & L. Allan (Eds.), Timing and time perception (pp. 298-321). Annals of the New York Academy of Sciences: New York

Miller, G.A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. Psychological Review, 63, 81-96.

Morris, P.E. (1984). The validity of subjective reports on memory. In J.E. Harris & P.E. Morris (Eds.), Everyday memory, actions and absent-mindedness (pp. 153-172). London: Academic Press.

Morton, J. (1968). Repeated items and decay in memory. Psychonomic Science, 10, 219-220.

Murdock, B.B., Jr. (1960). The distinctiveness of stimuli. Psychological Review, 67, 16-31.

Murdock, B.B., Jr. (1961). The retention of individual items. Journal of Experimental Psychology, 62, 618-625.

Murdock, B.B., Jr. (1962). The serial position effect of free recall. Journal of Experimental Psychology, 64, 482-488.

Murdock, B.B., Jr. (1963). Interpolated recall in short-term memory. Journal of Experimental Psychology, 66, 525-532.

Murdock, B.B., Jr. (1965). Effects of a subsidiary task on short-term memory. British Journal of Psychology, 56, 413-419.

Murdock, B.B., Jr. (1972). Short-term memory. In G.H. Bower (Ed.), The psychology of learning and motivation: Advances in research and theory (Vol. 5, pp. 67-127). New York: Academic Press.

Murdock, B.B., Jr., & Walker, K.D. (1969). Modality effects in free recall. Journal of Verbal Learning and Verbal Behavior, 8, 665-676.

Murray, D.J. (1968). Articulation and acoustic confusability in short-term memory. Journal of Experimental Psychology, 78, 679-684.

Neisser, U. (1976). Cognition and reality: Principles and implications of cognitive psychology. San Francisco: W.H. Freeman and Company.

Neisser, U. (1982). Memory observed: Remembering in natural contexts. San Francisco: W.H. Freeman and Company.

Nelson D.L., & Brooks, D.H. (1974). Retroactive inhibition of rhyme categories in free recall: Inaccessibility and unavailability of information. Journal of Experimental Psychology, 102, 277-283.

Nickerson, R.S. & Adams, M.J. (1979) Long-term memory for a common object. Cognitive Psychology, 11, 287-307.

Norman, D.A., & Bobrow, D.G. (1979). Descriptions: An intermediate stage in memory retrieval. Cognitive Psychology, 11, 107-123.

Parkinson, S.R. (1980). Aging and amnesia: A running span analysis. Bulletin of the Psychonomic Society, 15, 215-217.

Parkinson, S.R., Lindholm, J.M., & Inman, V.W. (1982). An analysis of age differences in immediate recall. Journal of Gerontology, 37, 425-431.

Peterson, L.R. (1969). Concurrent verbal activity. Psychological Review, 76, 376-386.

Peterson, L.R., Johnson, S.T., & Coatney, R. (1969). The effect of repeated occurrences on judgments of recency. Journal of Verbal Learning and Verbal Behavior, 8, 591-596.

Peterson, L.R., & Peterson, M.J. (1959). Short-term retention of individual verbal items. Journal of Experimental Psychology, 58, 193-198.

Poltrock, S.E., & MacLeod, C.M. (1977). Primacy and recency in the continuous distractor paradigm. Journal of Experimental Psychology: Human Learning and Memory, 3, 560-571.

Postman, L. (1961). The present status of interference theory. In C.N. Cofer (Ed.), Verbal learning and verbal behavior (pp. 152-179). New York: McGraw-Hill.

Postman, L. (1962). The temporal course of proactive inhibition for serial lists. Journal of Experimental Psychology, 63, 361-369.

Postman, L. (1976). Interference theory revisited. In J. Brown (Ed.), Recall and recognition (pp.157-181). London: Willey.

Postman, L., & Phillips, L.W. (1961). Studies in incidental learning IX: A comparison of the methods of successive and single recalls. Journal of Experimental Psychology, 61, 236-241.

Postman, L., & Phillips, L.W. (1965). Short-term temporal changes in free recall. Quarterly Journal of Experimental Psychology, 17, 132-138.

Postman, L., Stark, K., & Fraser, J. (1968). Temporal changes in interference. Journal of Verbal Learning and Verbal Behavior, 7, 672-694.

Raaijmakers, J.G.W., & Shiffrin, R.M. (1981). Search of associative memory. Psychological Review, 88, 93-134.

Raffel, G. (1936). Two determinants of the effect of primacy. American Journal of Psychology, 48, 654-657.

Rand, G., & Wapner, S. (1967). Postural status as a factor in memory. Journal of Verbal Learning and Verbal Behavior, 6, 268-271.

Raymond, B. (1969). Short-term and long-term storage in free recall. Journal of Verbal Learning and Verbal Behavior, 8, 567-574.

Raymond, B. (1971). Free recall among the aged. Psychological Reports, 29, 1179-1182.

Reitman, J.S. (1974). Without subrepticious rehearsal, information in short term memory decays. Journal of Verbal Learning and Verbal Behaviour, 13, 365-377.

Reynolds, J.H. (1977). Unavailable and inaccessible information in retroactive inhibition of paired associates. Journal of Experimental Psychology: Human Learning and Memory, 3, 68-77.

Ribot, T.A. (1882). Diseases of memory: An essay in the positive psychology. London: Kegan Paul, Trench.

Richardson, J.T.E., & Baddeley, A.D. (1975). The effect of articulatory suppression in free recall. Journal of Verbal Learning and Verbal Behavior, 14, 623-629.

Riegel, K.F. (1973). The recall of historical events. Behavioral Science, 18, 354-363.

Robinson, E.S., & Brown, M.A. (1926). Effect of serial position upon memorization. American Journal of Psychology, 37, 538-552.

Robinson, J.A. (1976). Sampling autobiographical memory. Cognitive Psychology, 8, 578-595.

Roediger, H.L., & Crowder, R.G. (1976). A serial position effect of United States Presidents. Bulletin of Psychonomic Society, 8, 275-278.

Roediger, H.L., Knight, J.L., & Kantowitz, B.H. (1977). Inferring decay in short-term memory: The issue of capacity. Memory & Cognition, 5, 167-176.

Rundus, D. (1980). Maintenance rehearsal and long-term recency. Memory & Cognition, 8, 226-230)

Rundus, D., & Atkinson, R.C. (1970). Rehearsal processes in free recall: A procedure for direct observation. Journal of Verbal Learning and Verbal Behavior, 9, 99-105.

Salthouse, T.A. (1980). Age and memory: Strategies for localizing the loss. In L.W. Poon, J.L. Fozard, L.S. Cermak, D. Arenberg, & L.W. Thompson (Eds.), New directions in memory and aging: Proceedings of the George A. Talland memorial conference (pp. 47-65). Hillsdale, NJ: Erlbaum.

Sands, S. R., & Wright, A.A. (1980). Serial probe recognition performance by a rhesus monkey and a human with 10- and 20-item lists. Journal of Experimental Psychology: Animal Behavior Process, 6, 386-396.

Schultz, R.W. (1955). Generalization of serial position in rote serial learning. Journal of Experimental Psychology, 49, 267-272.

Seamon, J.G., & Murray, P. (1976). Depth of processing in recall and recognition memory: Differential effects of stimulus meaningfulness and serial position. Journal of Experimental Psychology: Human Learning and Memory, 2, 680-687.

Shiffrin, R.M. (1970). Memory search. In D.A. Norman (Ed.), Models of human memory (pp. 375-447). New York: Academic Press.

Silverstein. C., & Glanzer, M. (1971). Concurrent task in free recall: Differential effects of LTS and STS. Psychonomic Science, 22, 367-368.

Smith, A.D. (1977). Adult age differences in cued recall. Developmental Psychology, 13, 326-331.

Smith, M.E. (1952),Childhood memories compared with those of adult life. Journal of Genetic Psychology, 80, 151-182.

Squire, L.R. (1974). Remote memory as affected by aging. Neuropsychologia, 12, 429-435.

Squire, L.R., Chace, P.M., & Slater, P.C. (1975). Assessment of memory for remote events. Psychological Reports, 37, 223-234

Squire, L.R. & Slater, P.C. (1975). Forgetting in very long-term memory as assessed by an improved questionnaire technique. Journal of Experimental Psychology: Human Learning and Memory, 104, 50-54.

Squire, L.R., Slater, P.C., & Chace, P.M. (1975). Retrograde amnesia: Temporal gradient in very long term memory following electroconvulsive therapy. Science, 187, 77-79.

Sumby, W.H. (1963). Word frequency and serial position effects. Journal of Verbal Learning and Verbal Behavior, 1, 443-450.

Thompson, C.P. (1982). Memory for unique personal events: The roommate study. Memory & Cognition, 10, 324-332.

Thompson, R.K.R., & Herman, L.M. (1977). Memory for lists of sounds by the bottle-nosed dolphin: Convergence of memory processes with humans? Science,, 195, 501-502.

Thorndike, E.L. (1913). The psychology of learning. New York: Teachers College.

Thorndike, E.L., & Lorge, I. (1944). The teacher's word book of 30,000 words. New York: Bureau of Publications, Teachers College, Columbia University.

Thurm, A.T. & Glanzer, M. (1971). Free recall in children: long-term store vs short-term store. Psychonomic Science, 23, 175-176.

Toglia, M.P., & Kimble, G.A. (1976). Recall and use of serial position information. Journal of Experimental Psychology: Human Learning and Memory, 2, 431-445.

Treat, N.J., & Reese, H.W. (1976). Age, pacing, and imagery in paired-associate learning. Developmental Psychology, 12, 119-124.

Trow, W.C. (1928). Recall versus repetition in the learning of rote and meaningful material, American Journal of Psychology, 40, 112-116.

Tulving, E. (1966). Subjective organization and effects of repetition in multi-trial free-recall learning. Journal of Verbal Learning and Verbal Behavior, 5, 193-197.

Tulving, E. (1968). Theoretical issues in free recall. In T.R. Dixon & D.L. Horton (Eds.), Verbal behavior and general behavior theory. Englewood Cliffs, NJ: Prentice-Hall.

Tulving, E. (1983). Elements of episodic memory. New York: Oxford University Press

Tulving, E., & Arbuckle, T.Y. (1963). Sources of intratrial interference in immediate recall of paired associates. Journal of Verbal Learning and Verbal Behavior, 1, 321-334.

Tulving, E., & Colotla, V. (1970). Free recall of trilingual lists. Cognitive Psychology, 1, 86-98.

Tulving, E., & Madigan, S.A. (1970). Memory and verbal learning. Annual Review of Psychology, 21, 437-484.

Tulving, E., & Patterson, R.D. (1968). Functional units and retrieval processes in free recall. Journal of Experimental Psychology, 77, 239-248.

Tulving, E., & Psotka, J. (1971). Retroactive inhibition in free recall: Inaccessibility of information available in the memory store. Journal of Experimental Psychology, 87, 1-8.

Tulving, E., & Thomson, D.M. (1973). Encoding specificity and retrieval processes in episodic memory. Psychological Review, 80, 352-373.

Tzeng, O.J.L. (1973). Positive recency effect in delayed free recall. Journal of Verbal Learning and Verbal Behavior, 12, 436-439.

Tzeng, O.J.L. (1976). A precedence effect in the processing of verbal information. American Journal of Psychology, 89, 577-599.

Tzeng, O.J.L., & Cotton, B. (1980). A study-phase retrieval model of temporal coding. Journal of Experimental Psychology: Human Learning and Memory, 6, 705-716.

Tzeng, O.J.L., Lee, A.T., & Wetzel, C.D. (1979). Temporal coding in verbal information processing. Journal of Experimental Psychology: Human Learning and Memory, 5, 52-64.

Underwood, B.J. (1945). The effect of successive interpolations on retroactive and proactive inhibition. Psychological Monographs, 59 (Whole No. 273).

Underwood, B.J. (1969). Attributes of memory. Psychological Review, 76, 559-573.

Underwood, B.J. (1977). Temporal codes for memories. Hillsdale, NJ: Erlbaum.

Underwood, B.J., & Freund, J.S. (1968). Effect of temporal separation of two tasks on proactive inhibition. Journal of Experimental Psychology, 78, 50-54.

Von Restorff, H. (1933). Uber die wirkung von bereichsbildungen in spurenfeld. Psychologisch Forschung, 18, 299-342.

Wagner, D.A. (1978). Memories of Morocco: The Influence of Age, Schooling, and Environment on Memory. Cognitive Psychology, 10, 1-28.

Waldfogel, S. (1948). The frequency and affective character of childhood memories. Psychological Monographs: General and Applied, 62 (Whole No. 291)

Warrington, E.K., & Sanders, H. (1971). The fate of old memories. Quarterly Journal of Experimental Psychology, 23, 432-442.

Warrington, E.K., & Silberstein, M. (1970). A questionnaire technique for investigating very long term memory. Quarterly Journal of Experimental Psychology, 22, 508-512.

Waugh, N.C., & Norman, D.A. (1965). Primary memory. Psychological Review, 72, 89-104.

Watkins, M.J. (1972). Locus of the modality effect in free recall. Journal of Verbal Learning and Verbal Behavior, 11, 644-648.

Watkins, M.J. (1974). Concept and measurement of primary memory. Psychological Bulletin, 81, 695-711.

Watkins, M.J., & Peynircioglu, Z.F. (1983). Three recency effects at the same time. Journal of Verbal Learning and Verbal Behavior, 22, 375-384.

Watkins, M.J., & Tulving, E. (1975). Episodic memory: When recognition fails. Journal of Experimental Psychology: General, 1, 5-29.

Watkins, M.J., & Watkins, O.C. (1974). Processing of recency items for free recall. Journal of Experimental Psychology, 102, 488-493.

Watkins, O.C., & Watkins, M.J. (1975). Buildup of proactive inhibition as a cue-overload effect. Journal of Experimental Psychology: Human Learning and Memory, 1, 442-452.

Watkins, M.J., Watkins, O.C., & Crowder, R.G. (1974). The modality effect in free and serial recall as a function of phonological similarity. Journal of Verbal Learning and Verbal Behavior, 13, 430-447.

Weisberg, R.W. (1980). Memory, thought, and behavior. New York: Oxford university Press.

Wells, J.E. (1974). Strength theory and judgments of recency and frequency. Journal of Verbal Learning and Verbal Behavior, 13, 378-392.

Whitten, W.B.,II. (1978). Output interference and long-term serial position effects. Journal of Experimental Psychology: Human Learning and Memory, 4, 685-692.

Whitten, W.B. II, & Leonard, J.M. (1981). Directed search through autobiographical memory. Memory & Cognition, 9, 566-579.

Wickelgren, W.A. (1965a). Acoustic similarity and intrusion errors in short-term memory. Journal of Experimental Psychology, 70, 102-108.

Wickelgren, W.A. (1965b). Acoustic similarity and retroactive interference in short-term memory. Journal of Verbal Learning and Verbal Behavior, 4, 53-61.

Wickens, D.D. (1972). Characteristics of word encoding. In A.W. Melton & E. Martin (Eds.), Coding processes in human memory (pp. 191-215). Washington, D.C.: Winston, 1972,

Wickens, D.D., Born, D.C., & Allen, C.K. (1963). Proactive inhibition and item similarity in short-term memory. Journal of Verbal Learning and Verbal Behavior, 2, 440-445.

Winograd, E. (1968). List differentiation, recall and category similarity. Journal of Experimental Psychology, 78, 3, 510-515.

Wolff, P.L. (1966). Trace quality in the temporal ordering of events. Perceptual and Motor Skills, 22, 283-286.

Wright, R.E. (1982). Adult age similarities in free recall output order and strategies. Journal of Gerontology, 37, 76-79.

Yntema, D.B., & Trask, F.P. (1963). Recall as a search process. Journal of Verbal Learning and Verbal Behavior, 2, 65-74.

Zimmerman, J., & Underwood, B.J. (1968). Ordinal position knowledge within and across lists as a function of instructions in free-recall learning. Journal of General Psychology, 79, 301-307.

APPENDIX

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1. Experiment 1: Word lists

2. Experiment 2: Word lists

3. Experiment 3: Word lists

4. Experiment 4: Word lists for categorized and uncategorized materials

5. Experiment 5: Letter, questionnaire and parking map given to subjects

6. Experiment 6: Letter and questionnaire posted to subjects

7. Experiment 7: Letter and questionnaire posted to subjects for the target and second visits to APU

8. List of Abbreviations

9. Anova tables from Experiments 1, 4 and 5.

(Word lists for experiment 1)

1	2	3	4	5	6
Writing	Skirt	Risk	Pigeon	Groan	Emotion
Autumn	Block	Harm	Jack	Income	Relief
Vice	Mortal	Mouse	Appeal	Science	Spite
Howl	Curse	Fashion	Bench	Display	Acre
Sink	Dart	Lamb	Flash	Style	Scratch
Permit	Murder	Frost	Slave	Bureau	Bush
Haste	Charity	Main	Lunch	Lumber	Theory
Courage	Strain	Tobacoo	Brush	Bite	Council
Boot	Lodge	Vision	Wool	Track	Deposit
Welcome	Protest	Sorrow	Park	Birth	Joke
Tower	Ability	Verse	Failure	Stove	Dispute
Route	Flesh	Hate	Temper	Armour	Hunter
Loan	Habit	Swell	Ideal	Triumph	Wreck
Hedge	Blanket	Cure	Staff	Arrival	Hammer
Excuse	Weapon	Belief	Trim	Wage	Widow
Brain	Brass	Area	Vale	Garment	Fencing

7	8	9	10	11	12
Extra	Canal	Whirl	Virtue	Mystery	Servant
Surface	Visitor	Angel	Earl	Cherry	Pity
bargain	Spoon	Suspect	Straw	Incline	Task
Genius	Barrel	Poison	Flock	Bloom	Cellar
Author	Maiden	Sand	Grave	Coach	Insect
Chain	Volume	Lily	Rescue	Finance	Shower
Mixture	Hail	Delight	Tent	Hero	Rope
Glimpse	Crime	Scream	Potato	Pillow	Frame
Vine	Shirt	Fork	Fortune	Victim	Driver
Shame	Navy	Troop	Seal	Magic	Supper
Grouth	Veil	Sight	Beast	Orange	Herd
Lamp	Prayer	Priest	Freight	Retreat	Doll
Tumble	Neglet	Novel	Grief	Fever	Whisper
Spare	Horn	Scare	Dignity	Bath	Blade
Liquid	Mass	Jewel	Warrior	Advice	Trial
Wedding	Lane	Gleam	Opening	Effect	Bunch

(Word lists for Experiment 1)

13	14	15	16
Harvest	Junior	Curve	Pattern
Luck	Luxury	Nurse	Apple
Nail	Rapid	Metal	Male
Globe	Boast	Bond	Roar
Series	Terror	Lion	Deer
Tailor	Port	Mirror	Cake
Freedom	Radio	Robin	Peasant
Juice	Highway	Trunk	Horror
Duck	Merit	Venture	Deck
Shed	Error	Wheat	Sheet
Despair	Button	Flag	Crow
Remedy	Wine	Trick	Feast
Column	Defense	Weep	Motor
Wisdom	Channel	Ribbon	Aunt
Grip	Steam	Feeling	Humour
Career	Hunger	Charm	Pocket

(Word lists for Experiment 2)

- One of the 2 randon orders -

1	2	3	4
Hiena	Camelo	Gazela	Bufalo
Marta	Puma	Alce	Lince
Jumento	Bezerro	Cabra	Bode
Texugo	Morsa	Lontra	Leucisco
Sapo	Sardao	Lagarto	Ra
Pantera	Girafa	Leopardo	Zebra
Visao	Iguana	Impala	Lama
Crocodilo	Jacare	Cagado	Tartaruga
Coelho	Raposa	Esquilo	Castor
Potro	Cordeiro	Burro	Rato
Macaco	Leao	Tigre	Elefante
Antilope	Cangaru	Gorila	Hipopatamo
Rena	Lobo	Veado	Urso
Carneiro	Porco	Vaca	Touro
Fuinha	Toupeira	Javali	Chacal

(Word lists for Experiment 3)

1	2	3	4	5	6
Zebra	Squirrel	Steer	Poney	Beaver	Gazell
Llama	Mouse	Donkey	Tiger	Rat	Sheep
Mink	Turtle	Elephant	Reindeer	Colt	Hyena
Pig	Cougar	Hog	Panther	Wolf	Kangaroo
Gorilla	Mole	Tortoise	Walrus	Lynx	Lion
Roach	Buck	Jackass	Rabbit	Elk	Mule
Goat	Camel	Fox	Impala	Frog	Otter
Weasel	Bear	Giraffe	Bull	Cow	Badger
Calf	Ox	Iguana	Deer	Bison	Leopard
Buffalo	Lizard	Lamb	Ape	Monkey	Coyote

(Word lists for Experiment 4)

- categorized words -

1	2	3	4	5
Mule	Hyena	Donkey	Deer	Sheep
Lamb	Cow	Buffalo	Kangaroo	Hog
Frog	Llama	Pig	Roach	Tortoise
Walrus	Mole	Cougar	Giraffe	Bear
Rabbit	Squirrel	Gorilla	Elk	Panther
Calf	Otter	Lynx	Beaver	Jackass

6	7	8	9	10
Steer	Badger	Camel	Zebra	Wolf
Leopard	Pony	Weasel	Coyote	Impala
Colt	Goat	Ape	Buck	Ox
Fox	Rat	Lion	Elephant	Tiger
Bison	Turtle	Iguana	Gazelle	Reindeer
Mouse	Mink	Bull	Lizard	Monkey

(Word lists for Experiment 4)

- uncategorized words -

1	2	3	4	5
Wine	Coat	Ticket	Orange	Winter
Oat	Bird	Cattle	Student	Band
Diamond	Ocean	Harbour	Forest	Flame
Ball	Dawn	Salt	Ice	Cake
Fat	Sheet	Bed	Midnight	Teacher
Church	Tent	Road	Body	Ship

1	2	3	4	5
Potato	Brook	Chicken	Nurse	Sand
Darkness	Honey	Wood	Flag	Nail
Book	Gun	Hospital	Apple	Letter
Grave	Square	Supper	Smoke	Garden
Song	Oil	Bridge	Ring	Brother
Car	Mountain	Family	Knee	Coffee

(Letter given to subjects on Experiment 5)

25th Nov 1982

Did you come in by car today? If so, where did you park your car? And yesterday? And the day before?

We are interested in memory for - and forgetting of - repeated everyday events. We would be extrememely grateful if you would be prepared to help us by trying to remember where you parked your car on each occasion over the last 2 weeks. You may find this an impossible task, but please recall what you can. Needless to say, what is forgotten is just as interesting as what is remembered.

One final point: it is important that you fill this in, if at all possible, between now and tea time - otherwise next morning's parking may well disrupt your memory of today's.

This is an experiment we can not do on the subject panel (except by inviting them every day for 2 weeks).

We would be very grateful for your help.

Alan Baddeley
Amancio Pinto

Questionnaire

Please use the appended plan to report the location in which you parked your car. Locations are of course approximate, so

if your car was for instance between location 57 and 58, respond 57/58;

if you did not bring your car on a particular occasion, please respond 0;

if you have absolutely no idea where you parked, please respond (---);

if you are unsure, guess.

Complete in any order you wish, but please do not use diaries or external memory aids.

Where was your car parked at:

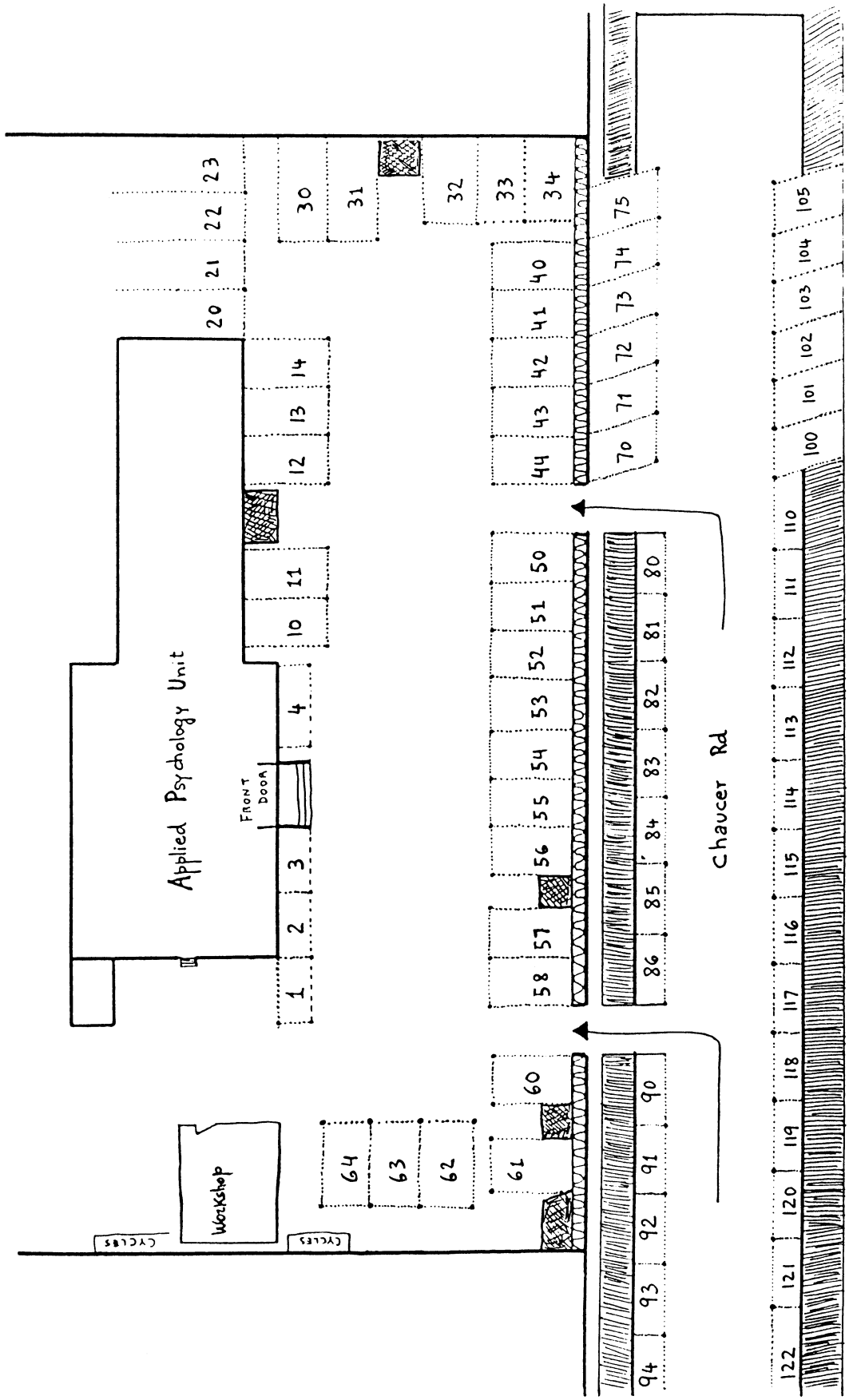
		11.30 am	3.30 pm
Wednesday,	10th Nov	--------	--------
Thursday,	11th Nov	--------	--------
Friday,	12th Nov	--------	--------
Monday,	15th Nov	--------	--------
Tuesday,	16th Nov	--------	--------
Wednesday,	17th Nov	--------	--------
Thursday,	18th Nov	--------	--------
Friday,	19th Nov	--------	--------
Monday,	22nd Nov	--------	--------
Tuesday,	23rd Nov	--------	--------
Wednesday,	24th Nov	--------	--------
Thursday,	25th Nov	--------	--------

0 = Did not come by car
--- = Absolutely no memory of location

Car Number: ----------

Name: ----------

Please place completed forms in Alan Baddeley's pigeon hole.



Map of the parking area of the Applied Psychology Unit

(Note: In Experiment 5, the numbers between 80 and 122 were omitted).

(Example of the letter send to subjects on Experiment 6)

Dear

Today (e.g., or last week, last month) you came to take part in testing at APU. Did you come in by car? If so, can you recall where you parked your car?

We are interested in memory for - and forgetting of - repeated everyday events. We would be extremely grateful if you would be prepared to help us by trying to remember where you parked your car on this occasion. You may this an impossible task, but please recall what you can. Needless to say, what is forgotten is just as interesting as what is remembered.

We would be very grateful for your help.

Yours sincerely,

Please use the appended plan to report the location in which you parked your car. Locations are of course aproximate, so
if your car was for instance between location 57 and 58, respond 57/58;
if you have absolutely no idea where you parked, please respond (---);
if you are unsure, guess.

Where was your car parked when you came to take part in testing at the Applied Psycnology Unit today (e.g., or last week, last month)?

Name: ..... Car number: .....

Date: ...../...../.....

Please cut the botton half of this page after answering the question, place it inside the stamped envelope and post to MRC Applied Psycnology Unit.

Thank you very much

(Example of the letter send to subjects in the retroactive interference group, Experiment 7)

- TARGET VISIT -

Dear

You have I believe come to the Applied Psychology Unit to take part in testing twice during May, on both occasions by car.

We are interested in memory for - and forgetting of - repeated everyday events, and in this conection would be extremely grateful if you would be prepared to help us by trying to remember where you parked your car on the first of these occasions, namely May ( ) when you attended the Unit after 6 p.m. to take part in group testing. You may find this an impossible task, but please recall what you can. Needless to say, what is forgotten is just as interesting as what is remembered. It is important that you do this before going on to open the second envelope.

We would be very grateful for your help.

Yours sincerely,

Please use the appended plan to report the location in which you parked your car. Locations are of course aproximate, so

if your car was for instance between location 57 and 58, respond 57/58;

if you have absolutely no idea where you parked, please respond (---);

if you are unsure, guess.

Where was your car parked when you came to take part in testing at the Applied Psychology Unit on May ( ) after 6 p.m.?

Name: ..... Car number: .....

Today's date: ...../...../.....

Please cut the botton half of this page after answering the question, place it inside the stamped envelope and post to MRC Applied Psychology Unit. Before doing so please open the second envelope. Thank you very much.

(Example of the letter send to subjects in the retroactive interference group, Experiment 7)

- SECOND VISIT -

Dear

We would also like you to remember where you put your car on the second, and we believe most recent visit to the APU. This occurred on May ( ) after 6 p.m. Please however do not attempt to remember this until after you have completed the previous form asking where you parked on the first of the two occasions.

We would be very grateful for your help.

Yours sincerely,

Please use the appended plan to report the location in which you parked your car. Locations are of course aproximate, so
if your car was for instance between location 57 and 58, respond 57/58;
if you have absolutely no idea where you parked, please respond (---);
if you are unsure, guess.

Where was your car parked when you came to take part in testing at the Applied Psychology Unit on May ( ) after 6 p.m.?

Name: ..... Car number: .....

Today's date: ...../...../.....

Please cut the botton half of this page after answering the question, place it, together with the answer to the first question inside the stamped envelope and post to MRC Applied Psychology Unit. Thank you very much.

List of Abbreviations

APU	-	Applied Psychology Unit
Anova	-	Analysis of variance
D.CD	-	Delayed recall in the continuous distractor paradigm
D.FR	-	Delayed recall in the free recall task
I.CD	-	Immediate recall in the continuous distractor paradigm
I.FR	-	Immediate recall in the free recall task
IPI	-	Interpresentation interval
IQ	-	Intelligence quotient
LTM	-	Long-term memory
PI	-	Proactive interference
PM	-	Post meridiem: After noon
PM	-	Primary memory
RI	-	Retroactive interference
RI	-	Retention interval
RPI	-	Release from proactive interference
SEC.	-	Seconds
SM	-	Secondary memory
SPF	-	Serial position function
STM	-	Short-term memory
$\bar{X}$	-	Mean

Anova from page 175:
1 Between (Young vs Elderly)
1 Within (4 task conditions).

```
BW-analysis of DATAFILE:   DYO:RECENCY3.AGE;4

Adder=      0.00  Divisor=      1.00 Transform=0
Adder=      0.00  Divisor=      1.00 Transform=0

 ANALYSIS OF VARIANCE  1 BETWEEN  1 WITHIN

SOURCE          DF          SS            MS        F      P

SUBJ            47     6341.120
B1               1     1931.672     1931.672    20.15  0.0000
EB1             46     4409.448       95.858

W1               3      799.891      266.630    21.07  0.0000
W1B1             3       36.099       12.033     0.95  0.4180
EW1B1          138     1746.260       12.654

W              144     2582.250


TSQ/N=      65305.6302       N=   192         SST=      8923.3698


STORAGE REQUIRED=     22/ 1300
PROGRAM COMPLETED SUCCESSFULLY
```

Anova from pages 180-181:
1 Between (Young vs Elderly)
3 Within:
W1 - (PM vs SM stores)
W2 - (CD vs FR tasks)
W3 - (Immediate vs Delayed recall).

ANALYSIS OF VARIANCE 1 BETWEEN 3 WITHIN

SOURCE	DF	SS	MS	F	P
SUBJ	47	195.370			
B1	1	58.985	58.985	19.89	0.0001
EB1	46	136.385	2.965		
W1	1	168.673	168.673	108.07	0.0000
W1B1	1	9.406	9.406	6.03	0.0179
EW1B1	46	71.792	1.561		
W2	1	1.563	1.563	2.82	0.1001
W2B1	1	0.726	0.726	1.31	0.2586
EW2B1	46	25.532	0.555		
W3	1	16.792	16.792	47.25	0.0000
W3B1	1	0.006	0.006	0.02	0.8984
EW3B1	46	16.348	0.355		
W12	1	1.414	1.414	2.26	0.1398
W12B1	1	0.011	0.011	0.02	0.8929
EW12B1	46	28.806	0.626		
W13	1	12.077	12.077	29.80	0.0000
W13B1	1	0.154	0.154	0.38	0.5401
EW13B1	46	18.645	0.405		
W23	1	6.907	6.907	24.72	0.0000
W23B1	1	0.225	0.225	0.81	0.3740
EW23B1	46	12.854	0.279		
W123	1	0.930	0.930	3.49	0.0680
W123B1	1	0.709	0.709	2.66	0.1095
EW123B1	46	12.247	0.266		
W	336	405.819			

TSQ/N= 2087.4013 N= 384 SST= 601.1887

STORAGE REQUIRED= 56/ 1300
PROGRAM COMPLETED SUCCESSFULLY

Anova from page 236:
1 Witnin (10 categorized word lists).

```
BW-analysis of DATAFILE:   DYO:SLIDE1.ANI;2

 FORMAT=(20X,10(F1.0,1X))
Adder=      0.00  Divisor=      1.00 Transform=0

 ANALYSIS OF VARIANCE  0 BETWEEN  1 WITHIN

SOURCE          DF          SS            MS        F     P

SUBJ            31       113.588

W1               9        62.750         6.972    3.88  0.0001
EW1B           279       500.850         1.795

W              288       563.600

TSQ/N=       1852.8125      N=   320        SST=       677.1875

STORAGE REQUIRED=     34/ 1300
PROGRAM COMPLETED SUCCESSFULLY
```

Anova from page 236:
1 Within (10 uncategorized word lists).

```
BW-analysis of DATAFILE:   DYO:SLIDE1.WOD;3

 FORMAT=(20X,10(F1.0,1X))
Adder=      0.00  Divisor=      1.00 Transform=0

 ANALYSIS OF VARIANCE  0 BETWEEN  1 WITHIN

SOURCE          DF          SS            MS        F     P

SUBJ            31        87.788

W1               9       102.250        11.361    6.04  0.0000
EW1B           279       525.150         1.882

W              288       627.400

TSQ/N=       812.8125       N=   320        SST=       715.1875

STORAGE REQUIRED=     34/ 1300
PROGRAM COMPLETED SUCCESSFULLY
```

Anova from page 236:
2 Within factors:
W1 (lists 1 to 5 versus 6 to 10) uncategorized words.

ANALYSIS OF VARIANCE 0 BETWEEN 2 WITHIN

SOURCE	DF	SS	MS	F	P
SUBJ	31	87.788			
W1	1	40.613	40.613	15.74	0.0004
EW1B	31	79.988	2.580		
W2	4	34.156	8.539	4.97	0.0010
EW2B	124	213.244	1.720		
W12	4	27.481	6.870	3.67	0.0073
EW12B	124	231.919	1.870		
W	288	627.400			

TSQ/N= 812.8125 N= 320 SST= 715.1875

STORAGE REQUIRED= 38/ 1300
PROGRAM COMPLETED SUCCESSFULLY

Anova from page 236:
2 Within factors:
W1 (lists 1 to 5 versus 6 to 10) categorized words.
W2 ("ghost" variable, 1/6; 2/7; (...) 5/10)

ANALYSIS OF VARIANCE 0 BETWEEN 2 WITHIN

SOURCE	DF	SS	MS	F	P
SUBJ	31	113.588			
W1	1	18.050	18.050	10.00	0.0035
EW1B	31	55.950	1.805		
W2	4	1.781	0.445	0.24	0.9138
EW2B	124	227.819	1.837		
W12	4	42.919	10.730	6.13	0.0002
EW12B	124	217.081	1.751		
W	288	563.600			

TSQ/N= 1852.8125 N= 320 SST= 677.1875

STORAGE REQUIRED= 38/ 1300
PROGRAM COMPLETED SUCCESSFULLY

Anova from page 247:
1 Within factor (4 dependent measures)

```
BW-analysis of DATAFILE:   DY0:PARK4.DAT;1

Adder=      0.00  Divisor=      1.00 Transform=0

 ANALYSIS OF VARIANCE  0 BETWEEN  1 WITHIN

SOURCE          DF          SS            MS        F      P

SUBJ            40     5826.244

W1               3      426.848       142.283   23.65  0.0000
EW1B           120      721.902         6.016

W              123     1148.750

TSQ/N=       6942.0061       N=   164         SST=      6974.9939

STORAGE REQUIRED=     16/ 1300
PROGRAM COMPLETED SUCCESSFULLY
```