Bangor University

DOCTOR OF PHILOSOPHY

Determinants of specificity in autobiographical memory.

Healy, Helen G.

Award date:
1997

Awarding institution:
Bangor University

Determinants of Specificity in Autobiographical Memory

Helen G. Healy

A thesis submitted in fulfilment of the regulations for the degree of Doctor of Philosophy in the University of Wales: 1997

SUMMARY

Depressed and suicidal patients have difficulty in recollecting specific autobiographical events. In response to cue words they tend to generate summarised or general memories instead of specific events. The objectives of this thesis are to explore the mechanisms underlying the production of specific and general autobiographical memories in a non clinical population. The roles of imagery and working memory in the generation of autobiographical memories were investigated.

Four experiments examined how manipulating the imageability of the cue affected subsequent retrieval in autobiographical memory. The results show that cues high in imageability facilitated access to specific memories and that visual imageability was the most significant predictor of memory specificity compared to a range of other perceptual modalities. The effect of an experimental manipulation on retrieval style was examined by instructing participants to retrieve specific events or general events using high or low imageable words to cue memories. The results show that induction of a generic retrieval style reduced the specificity of images of future events. This models clinical findings with depressed and suicidal patients and suggests that associations between memory retrieval and future imaging share common intermediate pathways. A further experiment suggested that the imageability effects mediating the construction of specific memories may be in part due to the predicability of such retrieval cues.

The hypothesis that retrieval of specific autobiographical memories is more effortful compared to the retrieval of general memories was also investigated using a dual task paradigm. Although central executive function has been implicated many times in the monitoring of autobiographical retrieval, no direct assessment of executive capacity during retrieval has been made. The results showed no significant difference in the randomness of a keypressing task when specific or general autobiographical memories were retrieved in response to either high or low imageable cue words. A direct retrieval hypothesis was proposed whereby cues directly accessed specific events in autobiographical memory and the adoption of such a strategy enabled participants to maintain performance on the secondary task.

CONTENTS

ACKNOWLEDGEMENTS.

There are two people without whom I could not have completed this thesis. The first is my supervisor Professor Mark Williams, who was a constant source of guidance and encouragement throughout. His enthusiasm, commitment and patience helped me to learn a great deal and I am forever grateful to him . The second person who made it possible for me to complete this work is my husband David who was always there for me and hugely supportive at all times. Special mention must also be made of my two children, Justin and Sarah who can now claim back much of my time that is rightfully theirs. Finally my friends, too many to mention, but especially Bethan Henderson and Linda Williams for always listening with interest and support.

Chapter 1.

Theories of Memory

Autobiographical memory comprises different qualitative memories, which are used to construct past events. One dimension of contrast is that of general memories versus specific memories. Activities or events which recur frequently are represented in autobiographical memory as general memories, whereas specific memories of recurrent activities are usually significant in some distinctive way. The aims of this thesis are to investigate the processes underlying the specificity/generic dimension of autobiographical memory in retrieval. The empirical work falls into two main areas; firstly the functional role of imagery in autobiographical memory with particular reference to the construction of specific and general autobiographical memory is investigated. The second area of investigation focuses on the role of working memory and autobiographical memory. A dual task paradigm is used to examine capacity constraints involved in the retrieval of specific and general memories. The first 2 chapters provide some background material to the study of memory in general, while Chapter 2 reviews the development and organization of autobiographical memory. The role of emotion and autobiographical memory is then discussed in Chapter 3.

Some theoretical memory models that have been proposed to account for empirical findings in the past and in more recent years are considered. As the study of autobiographical memory is a relatively recent phenomenon, with the majority of studies occurring since the early eighties, it is important to consider its role and position in relation to previous and current models of memory and attention. Firstly a brief overview of the major theoretical approaches to the study of memory will be discussed followed by the relevant models of the separate memory subsystems.

There has been considerable effort devoted to understanding how human temporary storage of information is achieved. The first conceptual model of memory was postulated by William James (1890) who viewed memory as consisting of two subsystems; primary memory and secondary memory. Primary (working) memory it was argued supported consciousness while secondary (long term) memory reflects a permanent record of the past. This early simplified model of memory developed into a more complex multistore model in the sixties. Following the demonstrations by Peterson and Peterson (1959) and Brown (1958) that if rehearsal was prevented, very rapid forgetting occurred (within a few seconds), evidence for the distinction between short and long term memory began to be actively sought.

One of the major sources of evidence for a distinction between primary and secondary memory came from experiments involving short term retention of word lists. Participants typically show primacy and recency effects and the overall pattern is referred to as the serial position curve (Glanzer & Cunitz 1966). However if there is a filled delay of even a few seconds before recall is required then the primacy effect is retained but the recency effect disappears. After a delay the last few list items are remembered no better than items from the middle of the list. The effect of a delay on recency but not primacy was taken to suggest that primacy reflected a long term or secondary system while recency reflected the operation of a short term or primary memory system.

Short term and long term memory have also been dissociated through differences in the nature of memory coding. Conrad (1964) demonstrated that when participants are asked to retain a sequence of letters in order, memory performance is poorer when the letters sound very similar to one another. The acoustic similarity effect disrupts the order of recall of letters for short term serial recall. Baddeley (1966a;1966b) suggested that acoustic similarity appeared to affect short term storage and semantic similarity appeared to affect long term storage. The evidence suggesting that a short term storage system retains words in terms of their sounds while the long term system retains words in terms of their meaning supported the distinction between primary and secondary memory.

Further support for the dichotomous view of memory was provided by patients with neurological damage. The best known of these patients is H.M. described by Scoville & Milner (1957). Following surgery for the relief of severe epilepsy, HM suffered bilateral damage to the temporal lobes and to the hippocampus. He had a very pronounced amnesia with an inability to learn new information. Despite this, H.M. showed normal intelligence and was able to retain short sequences of digits. A number of other such patients have been described (e.g. Butters & Cermak, 1986; Damasio et al ,1985; Della Salla & Spinnler, 1986; Teuber, Milner & Vaughan, 1968; Wilson & Baddeley, 1988; Zola-Morgan, Squire & Ammaral, 1986). Such amnesic patients provide evidence for a distinction between a short term and a long term memory system. Patients demonstrating the reverse characteristics have also been described (Shallice & Warrington,1970; Warrington & Shallice 1969). However the neuropsychological evidence presented here for a dissociation between a short term and long term memory system is not as clear cut as it appears to be and the area of neuropsychological dissociations remains a much debated topic.

Despite the considerable body of evidence supporting this dichotomous view of memory, and its intuitive appeal, certain limitations were revealed. A first limitation emerged from research on the primacy or recency phenomenon. It was initially thought that the established effects of primacy reflect a long term or secondary memory system, while the effects of recency reflect the operation of a short term or primary memory system. While earlier studies seemed to provide very strong evidence for a distinction between two memory systems (Glanzer and Cunitz 1966), subsequent work has indicated that the recency effect may not after all uniquely reflect the operation of a short term store.

Studies by Baddeley and Hitch (1977), suggest that recency may be a phenomenon of long term storage as well as reflecting immediate free recall. Free recall of the details of rugby matches taking place over a period of several months showed the familiar serial position curve, with events early in the sporting season showing a primacy effect, and events taking place over the few weeks prior to the memory test showing a recency effect. It is clear that recency spread over several weeks could not reflect the operation of a short term memory system. Further potential problems for the modal model were raised by a demonstration of recency effects in long term memory in a range of studies by Bjork and Whitten (1972,1974), Tzeng (1973) and Watkins and Peynircioglu (1983).

A number of demented patients have been reported who had severely impaired verbal memory span but appeared to show normal recency

(Spinnler & Della Salla, 1988; Wilson, Bacon, Fox & Kaszniak, 1983). In normal (Martin 1978) and in patient populations (Della Salla, Pasetti, & Sempio 1987) that show normal recency and span, there are very poor correlations between span and measures of recency. In addition, memory span is invariably impaired by articulatory suppression (Baddeley, Thompson & Buchanan 1975; Levy1971; Murray 1968). However, recency is unaffected by concurrent articulation (Richardson & Baddeley 1975). Such evidence clearly undermines the link between recency effects and short term memory.

A second problem for the modal model concerned the learning assumption, whereby the probability that an item will be transferred to long term memory is a direct function of its time of maintenance in STS (Atkinson and Shiffrin 1968). Tulving (1966), demonstrated that this was unlikely and found that there was no evidence that previous repetitions of a list of words enhanced subsequent learning; simply repeating the words did not increase their accessibility. A similar lack of learning following exposure was observed in a range of studies by Morton (1967), Nickerson and Adams (1979). Previous assumptions that processing in STS enhances encoding and subsequent retrieval were not supported.

A number of studies suggest that information in the STS is encoded phonologically while long term storage requires semantic encoding (Baddeley 1966). Other studies have suggested that this is an oversimplification and some experimental work has demonstrated that the nature of the task determines the form of coding adopted by subjects. Hulme, Maughan & Brown (1991) have shown that memory span for words is higher than for non words. Baddeley and Levy (1971) have also demonstrated that subjects will encode verbal material meaningfully if there is sufficient time available and this is reflected by semantic similarity effects; if not subjects rely on phonological coding and show phonological similarity effects.

Apart from the difficulties in resolving the limitations outlined above, the two store model dealt only with verbal rehearsal and storage. It is clear that there must be a wide variety of strategies for storing material and in an attempt to encompass a more general processing approach, Atkinson and Schiffrin (1968; 1971) developed a multi-modal model of memory. They proposed that memory contains three separate stores through which information flows. New information first enters the sensory store, which holds visual, auditory, and tactile information very briefly. Information then passes into the second short term store where it is stored or processed by various 'control processes'. One such control process is rehearsal which determines whether information is passed into a third permanent store, a structure known as the long term store (LTS).

However the Atkinson & Shiffrin modal model did not fully develop the notion of control processes and it was unclear why some processes lead to better long term retention than others. For example, experimental evidence suggests that the more frequently an item is rehearsed, the more likely it is to be recalled (Rundus 1971). Emphasis on modes of processing rather than focusing on hypothetical long term and short term memory stores was proposed by Craik & Lockhart (1972).

The Levels of Processing Model.

The " levels of processing" theory emphasises the mode in which information is processed rather than the actual memory structures involved. Craik and Lockhart's (1972) model is based on the premise that information which is processed at a deep level is more likely to be remembered than information that is only processed at a shallow level. Orthographic encoding is considered to occur at the shallowest level, then phonological encoding, with semantic encoding occurring at the deepest level. There is considerable evidence suggesting that semantic orienting tasks facilitate retention better than non semantic orienting tasks (Craik and Tulving 1975). Objections to this theory have focused on the circularity of the levels of processing approach which stems in part from the problems associated with defining and measuring 'depth of processing'. Furthermore the approach was primarily concerned with the encoding functions in long term memory and the model said little about short term memory. Given these difficulties, the levels of processing model remains intuitively attractive but provides a less tractable theoretical framework than initially supposed.

While Craik and Lockhart viewed primary memory as a phenomenon arising from the maintenance of information at various levels of processing, Atkinson & Shiffrin (1968) viewed primary memory as a single multi-purpose working buffer or temporary working memory incorporating both storage and a variety of processing functions and acting as a means to transfer information into long term storage. It is the last of these assumptions that viewed a single flexible system as a gateway to long term memory that was seriously undermined by neuropsychological evidence.

Warrington & Shallice (1969) described a patient K.F. and Brasso et al (1982) described another patient P.V. who have severely impaired ability to retain more than one or two digits in a sequence. P.V. had normal long term learning for meaningful material but not for novel verbal material (foreign language words) or phonological sequences (nonwords). What posed a question for the gateway hypothesis of the modal memory model is that these patients have apparently normal long term learning ability. This means that they were able to transfer information into long term memory despite having a severe deficit in short term or working memory. These findings suggest that either working memory is not the gateway to long term memory or that working memory comprises several systems not all of which were damaged in the patients described. The limitations described in the dichotomous view of a primary and secondary memory and the further limitations with the multi modal model and the lack of specificity in the levels of processing approach advocated by Craik and Lockhart (1972) led to the development of a multicomponent model of working memory.

Working Memory Model

This model was specifically designed to account for the short term memory phenomena which previous multi-modal models were unable to accommodate and to address whether STS really does serve as a general working memory. Attempts to answer that question led to Baddeley and Hitch (1977) challenging the earlier concept of a unitary STS. They proposed instead a related but more complex concept; a multi-component working memory model. Research within this framework emphasised the mechanisms underlying cognitive tasks such as reasoning, comprehension, and learning.

The main difference between the working memory model and previous concepts of short term memory is that the former model is seen as a complex of stores and systems rather than as a unitary store (Baddeley and Hitch 1974; Baddeley, 1983, 1986). The working memory model comprises a limited capacity central executive interacting with two slave systems; a speech based phonological loop and the visuo spatial-sketch pad. The central executive described by Baddeley (1983, 1986) functions as a control system. It is a limited capacity, attentional system, responsible for co-ordinating the input and output of information to and from the subsidiary slave systems, and for selecting and operating control processes and strategies.

This working memory model of memory successfully accounts for a range of experimental and neuropsychological evidence. It also provides a useful conceptual tool for the study of a wide spectrum of psychological phenomena including the retrieval of personal memories from autobiographical memory. The role of the central executive and autobiographical memory will be discussed in more detail in Chapter 9.

Long Term Memory

As with the early concept of short term memory, the original formulation of the long term store by Atkinson and Schiffrin (1968) was considered to be over simplified. Further research into the organization of long term memory led to the generally accepted view that it is made up of a number of separate systems each with a different function.

Tulving (1972) argued that the LTS is made up of three separate components; episodic, semantic and procedural memory. He described episodic memory as being concerned with 'personal experiences and their temporal relations'. Semantic memory was defined as a system for receiving, retaining, and transmitting information about the meaning of words concepts and the classification of concepts. It represents decontextualised knowledge devoid of temporal and spatial relations. Procedural memory was described as being similar to Ryle's ' knowing how' memories and included memory for motor skills and problem solving. Tulving (1983) further conceptualised these memory systems in terms of the degree of conscious awareness they involved. He defined episodic memory as being 'autonoetic' or self knowing as it involves an awareness of having experienced an event without having specific knowledge of the actual learning incident. Episodic memories can in turn be assimilated into semantic memory, which he described as 'noetic' or knowing as it involves an awareness of the information stored but not its point of origin. At the deepest level of the structure is the procedural system , which requires no conscious recollection and is therefore defined as anoetic or 'not knowing'.

Although all three memory systems are considered to be functionally distinct, they also interact. The interdependence of the episodic and semantic memory systems makes it difficult to demonstrate their separate roles in normal subjects. Given that autobiographical memory shares certain common features and processes with both semantic and episodic memory systems, we next consider both of these memory systems in more detail.

Semantic Memory

Much research has been carried out into different aspects of the representation and organization of information in semantic memory. Some researchers have concentrated on the possible ways in which the meanings of words might be represented, i.e. semantics. Other theories have considered semantic memory in terms of sentences rather than individual words. Models based on computer programmes that comprehend language were developed in the 1960's and 1970's to explain the way information is represented in semantic memory such as Quillian's Teachable Language Comprehender (Quillian 1969). Other theorists have attempted to develop models based on schemata or knowledge structures.

The main theoretical frameworks propose retrieval based models for semantic memory. In the Collins and Quillian (1969) model, semantic memory is organized as a hierarchy of superset relations. Properties of concepts are stored only with the highest superset to which they can apply and in this model sentence verification of true and false statements were executed by searching this net. The most influential semantic model was that of Collins and Loftus (1975) which combined aspects from both feature comparison and network search models replacing the network search with a spreading activation process.

Such a model accounted for the different response strategies and for a considerable number of empirical findings. This theory has however been challenged as too broad and vague. The sentence verification paradigm " A robin is a bird -True /False ?" has according to Kintsch (1980) ceased to be useful in that the data obtained from such experiments do not sufficiently constrain theoretical alternatives. Nor do they permit us to decide whether semantic memory should best be modelled by network or feature theories or whether the basic operations in semantic memory are pattern matching, comparison, search processes, or spreading activation processes.

Another approach to understanding the processes involved in semantic memory adopts frame theory (Minsky 1975; Schank and Abelson 1977). This approach from semantic fields to frames and schemata is an important one because it finally takes us beyond the lexicon and confronts the problem of how knowledge is represented. Nelson (1979) distinguishes between concepts (birds, animals, fruit etc.), event structures (the relations and functions into which a concept enters e.g wash your face), scripts and frames (which contain several event structures and several concepts organized by a goal e.g. Schank's restaurant script) and categories (which are general and context free structures defining logical and not physical relations)

There is another dimension concerning the dimension of generality. Concepts may be specific (robin) or general (bird). Frames and scripts also range from the specific to the general. Categories may be specific e.g. in a particular taxonomic hierarchy or general where they become principles for the organization of knowledge. Schema are regarded as general categories and act as structural entities for organising knowledge (Kintsch & van Dijk 1978). Similar distinctions and categories have been identified in the structure and organization of autobiographical memory.

Episodic and semantic memory.

Most terms referring to different types of memory serve the function of dividing the larger domain of memory into smaller areas within which empirical observations and theoretical propositions are thought to be generalisable. Such divisions usually take the form of a dichotomy, for example the classical division between short term and long term memory and the subdivisions between those systems.

The last twenty years have seen considerable controversy as to the extent to which long term memory may be fractionated into subsystems. Tulving's (1972) suggestion of a distinction between semantic and episodic memory constituted the first of these proposals. According to Tulving these two systems differ from each other in terms of (a) the nature of stored information and (b) autobiographical versus cognitive reference, (c) conditions and consequences of retrieval and (d) their dependence on each other. Episodic memory receives and stores information about temporally dated episodes and events and temporal - spatial relations among these events. A perceptual event can be stored in episodic memory solely in terms of its perceptible properties or attributes and it is always stored in terms of its autobiographical reference to the already existing contents of the episodic memory store. Semantic memory is the memory necessary for the use of language. Semantic memory is well differentiated and includes organized knowledge that a person possesses about words and other verbal symbols, their meaning and referents, about relations among them, and about rules, formulas and algorithms for the manipulation of these symbols, concepts and relations. Unlike episodic memory which preserves temporal-spatial relations and refers to personally experienced episodes, information retrieved and stored in semantic memory represents linguistic translations of information retrieved about general concepts and their interrelations.

Little effort has been made to delineate episodic memory. However since Tulving (1972), several researchers have identified different types of episodic memory. Brown & Kulik (1977) discussed a particular form of episodic memory which they identified as 'flashbulb memories'. These memories refer to an event limited in time and surprising in nature. Neisser (1982) also discussed these memories referring to them as 'critical moments' or 'benchmarks'. Linton (1982) distinguished between events 'which may be conceptualised across large or small units of activity. Robinson (1976) distinguished between memories for specific incidents such as an accident and memories for general awareness of such experiences such as a "times spent working in X". Thus both Linton & Robinson identified two basic types of memories, one referring to a specific occurrence and one referring to a more amorphous generalisation of many events.

These types of autobiographical memories allow us to make two basic distinctions concerning autobiographical experience. The first distinction is between general and specific memories and it is equivalent to the distinction made by Robinson (1976) and Linton (1982). The existence of different types of episodic memories is an important issue at both a theoretical and heuristic level. At a theoretical level, differences between the underlying representation of personal memories could have some of the implications suggested by Tulving (1972) for the semantic/episodic distinction. Namely episodic memory types might differ a) in terms of the nature of the information stored; b) the conditions and consequences of retrieval; c) their vulnerability to interference resulting in the transformation and erasure of stored information and finally d) their dependence upon each other.

It is perhaps less likely that these types would differ to the same degree as the semantic/episodic distinction would with regard to autobiographical versus cognitive reference. However general and specific memories may differ in terms of what they represent about an experience in that period. Thus current views on memory taxonomy would suggest a broader interactive dynamic semantic/episodic system and within this framework autobiographical memory can best be regarded as a sub category of episodic memory (Larsen 1993; Baddeley 1993).

Autobiographical memory is therefore concerned with the cognitive mechanisms and processes by which we recollect past events. Research to date on autobiographical memory stems from different disciplines ranging from cognitive psychology, neuropsychology to social and clinical psychology with different methodologies adopted to address particular questions. The next chapter reviews the development and organization of autobiographical memory.

Chapter 2

The Development and Organization of Autobiographical Memory

While Linton (1986) identified a number of different retrieval strategies she adopted in recalling past events, it remains unclear how such strategies develop. The development of autobiographical memory is of interest because it reflects the functional importance of acquiring specific and general memories of events. The following chapter reviews the development and organisation of autobiographical memory. The importance of cueing to elicit memories in young children is also addressed. A number of different models of organisation in autobiographical memory are examined and the retrieval strategies used in the process of retrieving an autobiographical memory.

Development of Autobiographical Memory

The last decade has seen much research into the development of autobiographical memory. The critical questions addressed by Nelson (1986, 1991, 1993) were why do adults have so few specific memories of their earliest years and how does the ability to establish a personal or autobiographical memory develop? Early studies were primarily concerned with children's general event memory or scripts for familiar events (Nelson & Gruendel 1981). Children as young as 3 years had quite good and reliable representations of routine familiar happenings and could present a verbal account of them. Because the same children had poor representations of specific events in their lives (Hudson & Nelson 1986), it was tentatively concluded that generic memory preceded episodic memory in development.

Work by Hudson and other authors described above suggest that generic knowledge in the form of general event representations or scripts plays an important role in children's understanding and use of complex language, interpretation of and memory for stories and dramatic play and events for the organization of object categories (French & Nelson 1982; Lucariello & Nelson 1985; Nelson 1986; Nelson & Gruendel 1981). This formation of script memory or generic memory is also extremely functional and enables a person to guide actions and predict future encounters. Later work established that very young children as young as 12 months do have specific memories for particular episodes in their lives and also need an extensive amount of cueing or reinstatement to facilitate the recall of such memories.

Nelson (1992, 1993) distinguishes three types of memory; generic memory for familiar canonical events, episodic memory for specific (often novel) events and autobiographical memory for a particular type of episodic memory that becomes incorporated into a personal 'life story'. When a novel or different event is experienced by the young child e.g. a visit to a zoo, a representation of this trip will be made in what Nelson refers to as a temporary holding system of episodic memory. Following a second trip to another zoo this second experience of the same kind causes the event to be transferred to the long lasting or generic memory system. A partial reinstatement will recirculate the memory into the episodic holding system. It is suggested that a single episode may be copied from episodic to autobiographical memory given certain conditions such as social value or perceived significance to the child's self concept.

All that seems to truly distinguish episodic recall from generic event memory is the sense that 'something happened one time' in contrast to the generic 'things happen this way'. In Nelson's theory it is important to stress that not all episodic memory is autobiographical, only those events which have become incorporated into personal life time histories, for example first time experiences, etc. Thus autobiographical memory in Nelson's terms is specific, personal and long lasting and usually of significance to the self system. Phenomenally it forms one's personal life history. This approach is consistent with James' conception of episodic memory: " Memory requires more than mere dating of the fact in the past. It must be dated in my past" (James 1890, p. 650).

Autobiographical memory is thus a function that comes into play at a certain point in childhood when social conditions foster it and language facilitates it. Language serves as a mediator of the social value of shared memory and as the narrative vehicle through which memories are shaped. It thus becomes the medium through which specific memories can be reinstated and thus prolonged within the system, and provides a labelling device through which memories can be accessed. Autobiographical memory is a universally familiar experience and also a uniquely human one because of its dependence on linguistic representations of events (Tulving 1983).

A feature which might distinguish early episodic memories from true autobiographical ones is that extensive cueing is necessary to elicit evidence of the former (Nelson et al 1987; Hamond & Fivush 1991). This extensive cueing also however applies to older 6 th graders and for young children. Heavy reliance on cueing may be specific to eliciting verbal memories of past events. When children are able to show what they remember rather than tell what they remember, they show accurate memories for past events with minimal cueing and prompting (Bauer & Mandler 1989; Fivush, Kuebli, &

Clubb 1992; Price & Goodman 1990). Thus it is not clear that the length of time over which events are remembered or the extent to which early memories are dependent on cueing, differentiate young children's early memories for specific events from true autobiographical memories. This raises the issue of cueing and its role in evoking autobiographical memories. Clearly the nature of the cue word has direct implications for the type of memory elicited.

This social interaction model of the development of autobiographical memory is also endorsed by Hudson (1990), Pillemer & White (1989) and Fivush & Reese (1991) . On this view children gradually learn the forms of how to talk about memories with others and thus how to formulate their own memories as narratives. The influence of mother/child interaction is thus a critical variable in the development of autobiographical memory. A distinction was drawn by Tessler (1986) between narrative (elaborative) and paradigmatic (informational) interaction styles. Paradigmatic mothers tended to ask categorical questions such as " What does the squirrel have in his mouth?" compared to event related questions such as " See the squirrel burying the nut so that he can find it and eat it next winter". When mothers and children engage in a narrative form of discourse, the children subsequently recall much more information about their experiences and consequently develop richly textured autobiographical memories. Children who do not develop narrativising talk tend not to remember episodes in the same way; they remember different aspects of the event and remember it less as a connected whole than as series or collection of parts. Equally for such children, memories of the past will not be so important for defining themselves and understanding themselves and others (Fivush & Reese 1991).

In summary, extensive cueing is necessary to elicit specific memories from children. The fact that children's memory requires such specific probing to elicit memory for particular events is important. It suggests that general event representations occur prior to the emergence of specific autobiographical memory and is for some time the preferred mode of recollection. With language acquisition and other meta linguistic skills, and when children acquire a theory of mind (Perner 1991), children's memories become more specific and elaborate. This developmental perspective reflects the importance of the general-specific continuum and the development of encoding and retrieval styles. The retrieval of autobiographical memories is an active constructive process which may reflect the organization of information in autobiographical memory.

Organization in Autobiographical Memory

One central area of autobiographical memory research has focused on the organization of autobiographical memory and the consensus from a number of independently conducted studies is that autobiographical memory is highly structured (Linton, 1986; Barsalou 1988; Conway & Bekerian 1987; Conway & Rubin, 1993; Conway 1990a). Models of autobiographical memory that reflect the organization of the system have implications for how specific and general memories are retrieved.

Network models.

Early accounts of autobiographical memory in clinical groups used network theory and models to explain findings. A network model of memory has probably been the most influential in early models of memory and mood. According to such models emotion is represented in memory as part of a more general associative network. Bower (1981) proposed that emotions are represented by nodes in memory and such nodes send and receive spreading activation and are connected to other nodes with varying degrees of strength. Such an account is similar to that of semantic network theory (Collins & Quillian 1969). Within such a system a particular affective state can be regarded as a node in memory similar in character to the information originally encoded. Thus a number of "emotional addresses" can exist in such networks corresponding to different valences and in turn activated by compatible sources.

Studies by Isen and her colleagues (Isen, Shalker, Clark & Karp 1978; Isen & Daubman 1984; Isen, Daubman & Nowicki 1987; Isen 1990) have provided support for an explanation of the effects of emotion that is largely based on the network concept. A broad summary of these findings suggest that positive mood facilitates performance on divergent creative problem solving tasks. Negative affect however has rarely been shown to have effects opposite and symmetrical to those obtained with positive affect inductions. Isen (1990) reports that negative affect either fails to facilitate the recall of negative material or acts as a less efficient retrieval cue than a positive mood state. A possible explanation for this finding is that the primary function of positive affect is to broaden the context in which stimuli are interpreted and act as a cue for a large variety of material (Isen & Daubman 1984). Similarly Ikegami (1986) concluded from the domain of personal memory that positive affect is a richer category than negative affect and is connected to a more elaborate memory network.

While early research into mood and memory initially relied on network models to account for findings of spreading or preferential retrieval of material congruent with encoding and retrieval mood, increasingly such models have appeared inadequate to explain results. If affective state is used primarily as a retrieval cue in a network then it is surprising that despite accessing a narrower category of information, negative affect would not trigger the retrieval of more associated material in the same manner. In addition the network interpretation does not explain the amnesic effects found when extreme positive and negative affective states are induced (Leichtman & Ceci, 1993).

Also mood congruency results are assumed to reflect the structure of the network or the levels of activation of particular emotion nodes and their associates within the network. Such a structural emphasis neglects other concerns that are central to autobiographical researchers; namely the search strategies that are involved in retrieval from autobiographical memory, the organization of knowledge within that system, and finally the time course and decay of autobiographical memory. Hence possible alternatives to network models were proposed to provide a more processing oriented account than the mainly structural approach of the latter.

Structural or Hierarchical Models of Autobiographical Memory.

A hierarchical account of autobiographical memory was proposed by Barsalou (1988). According to Barsalou, the development of this theory was motivated by three main findings; firstly, the centrality of chronologically organized extended events in structuring subject's free recall protocols, secondly, the equivalent use of other organizations, (e.g. organization by activities, participants and locations) and finally the prevalence of summarized events in subject's protocols.

Extended events provide an efficient means of summarising a person's life and distil a large number of experiences into a single representation. When subjects are asked to retrieve information from a particular time period, they can retrieve the part of an extended time line that covers this period (e.g. my final year in college) and thereby provide a global account of what occurred. Such extended time periods can also be used to extract or retrieve specific instances of events that occurred within that period (e.g. sitting my final philosophy paper). Thus Barsalou (1988) suggests that extended event time lines may act as the primary organizers of autobiographical memories and in turn cue other extended events or specific instances. Similar cue elaboration has also been discussed by Norman and Bobrow (1979), Reiser (1985, 1986), Williams (1978) and Williams and Hollan (1981).

The second major structural component of this theory identified by Barsalou (1988) is the summarised event. This represents the type of event that occurs repeatedly and is similar to a generic personal memory or categoric memory described by Williams (1992). Barsalou (1988) using subjects' protocols from his original free recall study claims that summarised events are typically nested within an extended event. For example final year in college might involve trips to the pub with friends, going on mountain walks and sharing study sessions. In turn such summarised events may provide access to specific events by means of cue elaboration. The hierarchically organized knowledge provides a ready supply of retrieval cues, one of which may be capable of eliciting an exemplar from a sought after event.

Barsalou's model of autobiographical memory is similar to the models of MOP (memory organization packets) first proposed by Schank (1982) and a computer model of human event memory described by Kolodner (1983) which includes E-MOP (event-memory organization packets). Kolodner proposed that people have such E-MOPs for all the major event types they experience. A number of different independent studies support the notion that autobiographical memory is hierarchically organized (Linton, 1986; Conway & Bekerian 1987; Conway 1990a, 1992a; Schooler & Hermann 1992). Linton (1986) for instance in her longitudinal study of her own memory proposed that memory is hierarchically structured with mood tone forming the highest most abstract level of the hierarchy, followed by themes and sub-themes which either index or are part of extendures which in turn index events and episodes. General knowledge relating to lifetime periods from an individual's life forms the top level of the hierarchy *(e.g.when I lived in Ireland)*, intermediate knowledge in the form of general or extended events constitutes a second level (e.g. *when I worked in Galway)* and memories of specific events form the lowest level in the hierarchy (e.g. *my wedding day in Galway).* Within this hierarchy of personal knowledge, lifetime periods index general events, that in turn index specific memories and these indices are provided in the form of cues available at different levels in the hierarchy.

Conway's (1993) structural model of autobiographical memory provides further independent support for that of Barsalou (1988) and assumes that an autobiographical knowledge base consists of three levels; lifetime periods, general events and event specific knowledge. Lifetime periods represent extended periods or thematic events in a person's autobiography. Similarly Anderson & Conway (1993) propose that general events are organized in terms of contextually distinctive details that distinguish between different general events. Knowledge of phenomenal experiences and associated thematic or general event knowledge combine in a dynamic highly interconnected process to facilitate the retrieval and construction of personal event memory or specific autobiographical recollections. This entire process may be initiated around different levels of the hierarchy.

Event specific knowledge or specific memories form the lowest level in hierarchical autobiographical memory structures. Such knowledge tends to take the form of images, feelings and highly specific details. Brewer (1988) found that recall of sensory detail was closely associated with accuracy of recall. Similarly Johnson, Suengas & Rays (1988) found that perceptual knowledge of actual as opposed to imagined events was far greater for the former. Ross (1984) found that subjects learning to use a word processor over a number of training sessions were often reminded of the exact words they had edited in a previous session. These results all suggest that event specific knowledge is an important aspect of autobiographical memory.

The hierarchical structural model of autobiographical memory assumes that each layer or micro structure within that framework act as indices or cues to stimulate recollections and as such are closely connected. Conway (1993) suggests that event specific knowledge although indexed by structures in the autobiographical knowledge base may not itself be part of that knowledge base. According to this scheme the parts of autobiographical knowledge that comprise lifetime periods and general events are a relatively distinct part of a much larger general purpose knowledge base (Conway 1990a, 1990b 1992; Anderson & Conway 1993) whereas event specific knowledge is part of a separate memory system..

Neuropsychological evidence provides some support for this conjecture. Patients suffering from retrograde amnesia often appear to have some preserved access to lifetime periods and general events but usually have difficulty in retrieving specific memories from the period covered by their amnesia. Postulating a separate memory system for specific event knowledge also provides a plausible account of forgetting in autobiographical memory (Conway 1993), if it is assumed that the most vulnerable aspect of the autobiographical knowledge base are the indices from general event memory to more specific and detailed memories, and access to such events is impaired.

An extensive study of specific autobiographical memories has been reported by Brewer (1988). He investigated memory for randomly sampled autobiographical events and for subject related autobiographical events. The following aspects of each event was recorded by subjects; time, thoughts, actions, thoughts and actions, and rated the co-ordination of actions and thoughts for each event. Various ratings of each event were also recorded including category frequency, instance frequency, pleasantness, significance, emotional arousal and how goal directed a particular goal or action was. Results showed that memory for actions was superior to memory for thoughts and memory for memorable events superior to that for randomly sampled events. These findings are consistent with those of Reiser, Black and Abelson (1985) who found that contextual cues denoting activities mediates retrieval of specific memories.

Anderson & Conway (1993) suggest that both thematic and temporal knowledge may organise specific memory details. In a series of experiments subjects listed details of memories in free recall, in forward order (first to last), in reverse order, in terms of centrality, and in terms of interest value of details. Memory detail production rates were significantly higher under free recall and forward listing and details listed in free recall were associated with the most personally important detail in memory. Memory details are indexed by personal thematic knowledge and distinctive details and specific memories are organized along a temporal dimension and can be searched from beginning to end. These findings are consistent with previous studies of autobiographical memory, indicating that thematic and temporal knowledge are central to the organization of autobiographical memory and at the basic level of specific autobiographical memories.

The preferred form of access to memories appears to be by way of personally significant aspects of the remembered event and personally important distinctive details leads to fastest access to memories. Temporal order is also important in the organization and access to specific memories. Anderson & Conway (1995) found that searching specific memories from first to last detail provides fastest access to a specific and detailed memory. However in clinical groups this temporal order may be disrupted by subjects halting at an intermediate description in the memory search thus resulting in a truncated search and a consequent failure to access a specific event.

Thus the construction of autobiographical memories depends upon access to an autobiographical knowledge base and each layer of autobiographical knowledge whilst being organized hierarchically provides indices to the other levels and thus facilitates access (Conway & Bekerian 1987; Barsalou 1988; Williams 1988, 1992, 1995). Once access is gained to a particular level in the hierarchy the process of retrieval begins.

Retrieval and autobiographical memory.

Studies into the retrieval processes involved in autobiographical memory suggest that there are a number of strategic steps involved in the recall of personal memories. According to Williams & Hollan (1981) memories are accessed by a process of cyclical retrieval. The general retrieval process that follows involves three stages; find a context, search, and verify. This cycle commences with a cue word or memory description (Norman & Bobrow 1979) that initiates a search or trawl through autobiographical knowledge bases to retrieve an appropriate context (activity or place).

This search in turn leads to the generation of possible episodes which can be regarded as exemplars of the selected context. A verification procedure follows which involves the monitoring of memory output and a decision is made whether to respond or not. When the accessed knowledge does not satisfy the constraints of the evaluation phase or experimental constraints then a new retrieval cycle is initiated with a new memory description. Thus target information in long term memory is located by a series of retrieval cycles that successively hone memory descriptions until a suitable memory is accessed and the retrieval process then terminated.

Retrieval from memories of specific events appears to be an essentially problem solving exercise in which different stages in the retrieval process are cycled through as the search moves from the general to the specific. The use of categorical knowledge such as activities or locations in searching specific memories suggests that the events these memories represent may have been encoded in terms of the categorical knowledge structures used to process such events. Specific autobiographical memories appear to be structured as Schank (1982) suggested by the schemas and concepts used to process those events as they occurred (Barsalou 1988). Finally Conway (1990) suggests that the use of image based search strategies may assume that memories may in part be structured by the spatio-temporal context in which they were encoded. Further research is necessary to examine how differences in the nature of cues affect retrieval in autobiographical memory.

Earlier accounts of non specificity in autobiographical memory appealed to description theory as an explanatory framework (Norman & Bobrow 1979; Williams & Hollan 1981). According to this theory "retrieval is characterised as a process in which some information about the target item is used to construct a description of the item and this description is in turn used in an attempt to recover new fragments of information" (Williams & Hollan 1981,p. 87). Descriptions theory assumes that a person only encodes a limited amount of possible information like an incomplete list of properties or a partial image. To encode or retrieve any packet of information a partial description is formed that provides an initial entry point into the memory.

This description acts as an index for the memory packet. The major stages in such a retrieval process are find a context - search - and verify similar to those outlined by Williams & Hollan (1981). Reiser, Black & Abelson (1985) adopted a similar framework in studies looking at the priming of autobiographical events using activities or general actions. First, experiences are retrieved by accessing the knowledge structures used to encode the event and then by specifying features that discriminate an event with the target features from others indexed within that context. Secondly, the retrieval query is elaborated using general information contained within knowledge structures to predict additional features of the target event thus directing searches to the final pathway and the construction of the specific event.

Williams & Dritschel (1988,1992) adopted a descriptions theory framework to describe results of autobiographical memory recall obtained with depressed patients. It was deemed useful to conceive of organizing contexts or descriptions or fragmentary information used in the encoding and retrieval of personal memories since they have clear implications for how the system may be affected and in turn be affected by levels of depression. It was assumed that patients were accessing intermediate descriptions but stopping short of a specific example and that it was such a truncated search that resulted in overgeneral memory responses.

Williams (1996) suggested that an increase in intermediate categoric descriptions may block the retrieval of specific events in depressed and suicidal people. For example in response to a cue word such as 'unhappy' depressed groups tend to activate a network of negative categoric descriptions including references to lack of friends, letting down parents, failure at exams etc. The result is an over-elaboration of such categories which encourages ruminative self focus, this process has been termed 'mnemonic interlock' by Williams (1993). It is suggested that this mnemonic interlock can only be overridden at high cost of effort so that individuals who have reduced working memory or central executive capacity will find it particularly difficult to break the deadlock and access specific memories. This aspect will be discussed in detail in Chapter 9.

The findings reviewed in these studies of retrieval processes suggest that a number of factors may mediate the retrieval of specific memories. The first factor is the general retrieval process outlined by Williams & Hollan (1981) and the framework of find a context- search -verify model. This framework supports the structured hierarchical model of autobiographical memory and the notion that the retrieval of personal event memories is a dynamic and constructive and at times effortful process. The nature of the cue word in terms of imageability or content is a critical determinant of subsequent memory retrieval. The third factor is recency, where memories of recent events tend to be generally more available than memories of remote events. A further factor mediating remembering is the structure of the encoding environment where aspects of the encoding environment (for example categorical activities) are utilised by the retrieval process in accessing memories. Models of autobiographical memory that reflect the organisation of the system have implications for how specific and general memories are retrieved. The role of working memory in monitoring the output at the end of the retrieval cycle is another factor to consider and this aspect of retrieval is discussed in Chapter 8.

The hierarchical framework model of autobiographical memory has been a useful heuristic to explain patterns of retrieval from autobiographical memory. According to such models, the process of recollection is perceived as a dynamic cognitive operation involving search strategies, monitoring and verification. Retrieval is mediated via the hierarchical elements described. By accessing this retrieval framework relating to one particular life period or event, a major organisational support structure is initiated that guides retrieval and reconstruction of specific autobiographical episodes.

Hierarchical models of autobiographical memory raise the question of cueing and how differences or variation in the nature of the cues used in the standard autobiographical memory task affects the retrieval of specific memories. Previous work has shown correlations between the imageability of the cue word and memory specificity Williams (1992). The motivation to examine the mechanisms underlying the production of specific and general autobiographical memories stemmed from research with depressed and suicidal groups. The following chapter reviews autobiographical memory and emotion and the role of imagery and cues in the retrieval of autobiographical memories.

Chapter 3

Autobiographical Memory and Emotion.

The distinction between specific and general memories in a clinical context has been the subject of much research. It is this aspect of autobiographical memory that is the focus of this chapter, and the consistent finding that depressed individuals tend to retrieve 'overgeneral memories'. This phenomenon raises a number of questions. What mechanisms underlie this process? What factors determine specificity of recall in a non clinical group? Is autobiographical memory subject to the same influences as other aspects of memory? Is autobiographical memory retrieval linked to working memory and if so how? What is the role of imagery in autobiographical memory? This chapter examines the relationship between autobiographical memory and depression with particular focus on the qualitative nature of those personal memories.

In the original study which examined mood congruent memory in people who had recently attempted suicide Williams & Broadbent (1986) found that such subjects were not readily able to provide specific memories in response to positive and negative stimulus cue words. Twenty five patients who had recently taken an overdose and were still depressed were compared with twenty five matched hospital controls and twenty five subject panel control subjects. Ten cue words were presented similar to those used by Robinson (1976); five positive; *happy, surprised, interested, successful and safe* and five negative words; *clumsy, hurt, angry lonely and sorry.* All subjects were requested to recall an event that the word reminded them of, and that the event should be a specific event - something that had happened at a particular place and time and lasted no longer than a day. An example was used to illustrate what would and would not qualify as such an event. For example in response to a cue word ' happy' the type of memory required would be "at Jack's housewarming party last Saturday night" whereas a response taking the form of "shopping with my friends every Saturday in Chester" would not count as a specific memory. A practice session was given and subjects were given 60 seconds to retrieve a memory. Inter-rater reliability of memory specificity was 87% and 93% in agreement with the experimenter categories. This experiment is the basic paradigm used in all subsequent studies.

The results in terms of latency or the time taken by subjects to retrieve a specific memory supported previous findings on depression in that emotionally disturbed people had a longer latency to retrieve positive memories. This result however reflected a possible confound in the experimental design in that the longer latencies in the experimental group were the result of subjects initially retrieving overgeneral memories and then requiring prompting to recall a specific memory. On further analysis results showed two significant effects. Firstly there was a significant group main effect with the suicidal patients showing a tendency to be overgeneral in their first response. Secondly there was a significant interaction whereby suicidal subjects found the retrieval of specific memories to positive cue words particularly difficult.

Further cognitive function tests were performed to rule out the side effects of drug overdose as suicidal patients were tested between 36 and 96 hours following their overdose. A semantic processing task was used which had previously been shown to be sensitive to drug effects (Baddeley 1981). While this task showed a significant difference between the subject panel controls and the two other groups, (overdose and hospital controls), the latter groups showed no difference. Thus it appeared that the two patient groups were equally cognitively "sluggish" as each other compared to the non patient controls. This pattern was in contrast to the pattern of autobiographical memory results where only the overdose group showed a distinct pattern of overgenerality. Subsequent work has confirmed the robustness of these findings. Thus the phenomenon of non specificity in autobiographical memory retrieval in emotionally disturbed groups is a reliable phenomenon.

The question arises however as to whether these results could be due to the way in which events were cued in the experiments. The use of single cue words might be a particularly inappropriate way to cue personal memories and may be especially difficult for emotionally disturbed groups. Categorical knowledge such as activities and locations used in searching for specific memories, assumes that the events these memories represent may have been encoded in terms of the categorical knowledge structures used to process these events as they have occurred (Schank & Barsalou 1988). Reiser, Black & Kalamarides (1986) found that memory retrieval to compound cues naming contextualised actions (going to the cinema) and general action (finding a seat) was faster when cues were presented in the order of contextual action first rather than general action. Similarly Kolodner (1983) suggests that existing knowledge structures serve to facilitate the reconstruction and retrieval phase in providing an inherent plot structure or event type schema. Perhaps then the use of single emotive cues used in the early studies of autobiographical memory were sub-maximal for eliciting specific autobiographical memories.

However, Williams & Dritschel (1988) added activity cues to an emotionally valent noun (e.g. happiness - going for a walk) to see if providing an activity cue would assist the retrieval process. No differences were found in the pattern of results, with the suicidal group again demonstrating non specificity in recall. A further study examined depressed subjects perceptions of how much emotional and instrumental support they receive (Moore, Watts and Williams 1988) by presenting a series of positive and negative scenarios to depressed subjects and matched controls. Subjects were required to recall specific instances in each case. Results showed that despite cueing with vignettes in this way, rather than using single stimulus cue words, depressed subjects still tended to be overgeneral.

Evidence that the phenomenon of non specificity in autobiographical memory retrieval may generalise to other clinical groups was demonstrated in a further study by Williams & Scott (1988). Twenty in-patients with a diagnosis of major depression were matched with twenty subject panel controls for age, educational level and performance on Baddeley's Semantic Processing test. The depressed subjects retrieved specific memories 40% of the time compared with 70% in the control subjects. This finding was replicated by Puffet, Jehin-Marchot, Timsit-Berthier, & Timsit (1991), who found greater overgenerality in depressed patients. A recent study by Kuyken & Dagleish (1995) investigating a sample of clinically depressed patients (N=33) showed that depressed subjects recalled more general memories than controls replicating the work of Williams & Broadbent (1986), Moore et al (1988), Williams & Scott (1988).

Non specificity in autobiographical recall has also been found in patients with Post Traumatic Stress Disorder. McNally, Litz, Shin & Weathers (1994) in a study using Vietnam veterans with post-traumatic stress disorder were more overgeneral in recalling autobiographical memories when compared to combat veterans matched for amount of combat experience but without PTSD. McNally et al also suggest that a relative inability to retrieve specific personal memories may be related to one's inability to envision the future and that such overgenerality may be implicated in the problem solving deficits that occur in combat veterans with PTSD (Nezu & Carnevale 1987).

While non specificity in autobiographical memory has been clearly established in depressed, parasuicidal and in a clinical group with post-traumatic stress disorder, the finding does not generalise to anxious subjects. Two studies have examined the specificity of autobiographical memory in anxiety. Richards & Whittaker (1990) compared high and low anxious subjects. There was no evidence that high anxious subjects were more overgeneral in their memory. A further study by Burke & Matthews (1992) which used patients diagnosed as clinically anxious failed to find any evidence of overgenerality when compared to controls. Both studies did however find a mood congruent effect on the latency to retrieve events where anxious subjects were faster in retrieving events to threat related cues compared to happy ones.

To address the claim that an overgeneral mode of autobiographical recall may exist as a function of underlying trait psychopathology Williams & Dritschel (1988) examined 16 recovered patients who had attempted an overdose between three and fourteen months previously. This group was compared with a control group of current patients and a subject panel control group.

Results showed that the proportion of responses that were specific in ex patients (54%) was not significantly different from current patients (46%) , but that both of these groups were significantly different from controls (71%). Thus Williams and Dritschel (1988) conclude that non specificity in the recall of personal memories may be a long term cognitive style, which may in turn render depressed patients more vulnerable to mood swings.

Implications of non specificity in autobiographical memory.

Suggestions that non specificity in autobiographical memory may contribute to maintaining psychopathology has implications in terms of treatment and eventual long term recovery. A number of studies investigated the consequences of such non specificity in autobiographical memory. A longitudinal study by Brittlebank, Scott, Williams & Ferrier (1993) examined autobiographical memory in depressed patients during recovery. Patients were interviewed at admission, three months and seven months later. Two main findings emerged. Firstly, there was no significant increase in the specificity in autobiographical memory recall over this period. Overgenerality to neutral cue words did however fall as depression remitted but even patients in remission remained impaired in their memory specificity compared with normal or hospital control groups. This is consistent with the conclusion that overgeneral memory is a long term cognitive style rather than a form of retrieval that varies with short term mood changes.

The second finding in this study was that overgenerality assessed at admission predicted levels of depression seven months later. This illustrates the significance of this index of autobiographical function in depression and supports other measures of treatment response. Wahler & Afton (1980) demonstrated non specificity in autobiographical recall in women who had problems with their children. They suggested that such mothers had difficulties encoding specific information about stressful interactions with children. Participation in a subsequent parent training program revealed that mothers whose memories became more detailed and specific were found to have an improved relationship with their children on various independent measures of outcome. Those mothers whose memories were mostly non specific, however failed to benefit from this treatment program.

Recent work has shown that a significant number of depressed patients with a history of child sexual abuse continue to experience high levels of ongoing distress with regard to abuse related memories (Kuyken & Brewin 1994). Furthermore, depressed patients with a history of child sexual abuse have significantly more difficulty accessing specific memories than depressed patients with no history of abuse and this effect is particularly marked where it is associated with high levels of on-going distress for the abuse (Kuyken 1992, Kuyken & Brewin 1994). Such results are again consistent with the hypothesis that overgenerality in autobiographical recall reflects a particular cognitive trait or style that is particularly impaired in depressed or emotionally disturbed groups.

The phenomenon of non specificity in autobiographical memory recall has further clinical implications. Although early work showed that patients had particular deficits in recalling specific positive memories, later research has revealed that suicidal patients have a more general problem recalling specific memories from their past in response to both positive and negative cue words (Evans, Williams, Howells & O'Loughlin 1992). This study also examined whether such a memory deficit was also associated with poor problem solving. The definition of a problem and the generation of an alternative possible solutions requires an ability to address a memory 'database' efficiently.

Williams et al (1992) suggests that problem solving becomes inhibited because depressed patients attempt to use intermediate descriptions that they have retrieved as a database to generate solutions. This database is limited and restricted because of the lack of specific information. Such an account is consistent with models proposed for analogical problem solving. In solving through analogy individuals apply their knowledge of a base domain to a structurally similar target domain. Successful transfer requires that the base problem be disembedded from its specific context. This disembedding does not imply forgetting the original context but rather recognising the abstract relations that hold among elements of the problem (Brown 1989). For many interpersonal problems, efficient access to a database and instances of structurally similar target domains or specific autobiographical event memories is necessary to generate adequate solutions.

Evans et al (1992) used a test of interpersonal problem solving called the Means Ends Problem Solving Test (MEPS) to investigate the relationship between non specificity in autobiographical memory and problem solving in a group of suicidal patients. The mean effectiveness of solutions produced was significantly less in overdose patients than for a matched control group. Furthermore the degree of problem solving impairment was predicted by the degree to which participants failed to retrieve specific memories. These results are consistent with the model proposed above for analogical problem solving. Failure to access instances of similar target domains or a specific autobiographical memory results in impaired problem solving for overdose groups.

Non specificity in clinical groups-possible causes.

In order to understand the mechanisms responsible for overgeneral retrieval in depression, we need first to ask under what circumstances people use generic memory normally. The ability to summarise large numbers of individual episodes into a generic memory is functional, efficient and adaptive. General memories give access to large amounts of information which is necessary for everyday life. Much of the time, people do not need to describe detailed specific examples, the general gist of a number of memories is sufficient. The greater the frequency of an event, the more likely it is that time, place and other contextual information will be lost, and memories become general. It is possible that a continuum exists with unique episodic events at one end and generic knowledge schemas at the other (Barsalou 1988). Generic memory would occupy a position midway between autobiographical event memory and autobiographical facts (e.g. ones name or address).

However, there are reasons to think that such a frequency effect is not a complete explanation of overgeneral memories. Firstly, there are reliable individual differences in the extent to which people give overgeneral memories on an autobiographical memory task. It is not plausible to suppose that this reflects the increased frequency of all events recalled. Secondly, the research on depressed groups have shown that they are as likely to retrieve overgeneral memories to positive as well as negative words and yet there is abundant evidence that such individuals have had many more negative experiences than non depressed people. If frequency effects were responsible for the increase in general memories they should show greater tendency to be overgeneral to negative cues and this does not happen.

Williams (1996) suggests that it may be quite common for people to retrieve events in a generic form without having multiple experiences of the event, particularly if that novel event is seen as paradigmatic or representative. A schema or script based memory of that experience is constructed. Also Dritschel & Williams (1988) found no significant correlation between general memories and the frequency of the event. The retrieval system appears to have a strategy which delivers as output that which is seen as typical or paradigmatic independently of the frequency of the underlying event', (Williams 1996, p.128).

A similar strategy is shown by children where they form general memories based on a single encounter or experience. They assume that future occurrences will be consistent with the first experience. For example when asked to provide a memory following a first visit to Disneyland, one five year old reported;"You go in a hotel, you go on rides, you see Mickey Mouse etc,..(Hudson & Nelson 1986). Overgeneral retrieval may be partly due to a long term cognitive style which is consistent with the idea that some individuals may learn to use overgeneral encoding and retrieval strategies as a means to control affect and more particularly to minimise negative affect (Singer & Moffitt 1992).

While much of the early work with depressed and suicidal patients has concentrated on possible causes and correlates of non specificity in the retrieval of autobiographical memories, there have been no attempts to understand the processes and mechanisms underlying this specific -generic continuum. The aim of this thesis is to examine the processes underlying the production of specific and general autobiographical memories in a non clinical group. The role of imagery, the importance of cueing and the role of working memory in monitoring the retrieval of autobiographical memories are three aspects of autobiographical memory that are focused on.

Imagery, cues and Autobiographical Memory.

Williams (1996) suggested that contextual cues which are distinctive (highly imageable or concrete) will be successful at interrupting the categoric retrieval cycle and facilitate the retrieval of specific event memories. The nature of the cue is regarded as the critical determinant in eliciting specific memories as indeed early work by Conway (1988) and Reiser Black and Abelson (1985) suggested. The use of activity cues for example 'going to the cinema' facilitated the retrieval of specific instances of events. Similarly Williams & Dritschel (1988) showed a significant correlation between cue imageability and autobiographical memory specificity.

The nature of cues used to elicit autobiographical memories was further explored by Conway (1990) by examining associations between autobiographical memories and conceptual knowledge. Two classes of concepts or taxonomic categories (e.g. furniture, fruit, and sport) and goal derived categories (e.g. birthday presents, camping holidays and things to do at the seaside) were used as cues. While such concepts cannot be differentiated in terms of formal criteria definitions they do have characteristic differences. Taxonomic categories such as furniture and sport are primarily involved in the classification of objects and activities that occur in the environment and are associated in memory with decontextualised knowledge. In contrast goal derived categories are involved in " instantiating schema variables while achieving goals" (Barsalou 1985, p. 633).

Thus goal derived categories will tend to be associated in memory with schema specific knowledge. Autobiographical memories have also been found to be closely associated in long term memory with event knowledge (Barsalou 1988; Conway & Bekerian 1987a; Reiser, Black & Abelson 1985). Reiser et al (1985) demonstrated that cues comprised of actions in contexts (going to the cinema) were more effective for memory retrieval than cues that named an activity without naming a context (finding a seat). Conway & Bekerian (1987) found that event knowledge that was specific to an individual (e.g. when I lived with "X") provided fast access to associated general events (e.g. holiday in Italy) and speeded memory retrieval. Finally Barsalou (1988) observed that summarized event knowledge comprised a major type of autobiographical memory recall and was critical in the access of specific autobiographical memories. Current theorising suggests that goal derived concepts are closely associated with event knowledge and that the available evidence demonstrates a close association between autobiographical memories and event knowledge.

There are some reasons for believing that taxonomic categories are not in general associated with specific memories of experienced events. The sheer frequency of categories such as furniture and fruit encountered in the environment in comparison to birthday or seaside trips precludes the possibility of direct associations between taxonomic categories and autobiographical memories. Instead knowledge from taxonomic categories may be abstracted from numerous experiences and only this decontextualised knowledge is easily accessible when processing these concepts. Evidence in support of this view has been reported by Conway & Bekerian (1987a) who found that taxonomic categories such as furniture did not prime autobiographical memory retrieval to related cues such as chair.

Conway (1990) demonstrated that goal derived categories can prime autobiographical memories, while in contrast taxonomic categories produced no reliable effects. Although all memories were specific and of moderate personal importance, memories retrieved to goal derived categories were consistently more specific and personally important than memories retrieved to taxonomic categories. Further experiments confirmed this finding. Factors such as specificity of memory and date of memory appear to be partly related to retrieval times in that specific memories are retrieved more quickly than less specific memories and recent event are retrieved more quickly than less recent events.

One way to conceptualise the prime effects of goal derived categories demonstrated by Conway (1990) is in terms of spreading activation (Anderson 1983; Collins & Loftus 1975; Conway & Bekerian 1987a). According to this account, processing of a category prime activates corresponding long term memory representations such as event frames. If these representations directly index autobiographical memories then specific memories are also activated. This type of activation facilitates the retrieval of autobiographical memories. Another possibility is that on the majority of goal derived primes trials the prior processing of the primes lead to the activation of related event knowledge that facilitates the operation of strategic retrieval processes. The nature of cues whether goal derived, or cues reflecting activities, whether high or low in imageability are clearly critical factors influencing the retrieval of autobiographical memories and may in turn affect the strategy adopted during that retrieval process.

Current models of imagery emphasise the process of imaging and give little consideration to the functional role played by images. According to Conway

(1991) many imagery effects such as the beneficial effects of imagery upon remembering are not addressed by such models. Conway (1988) proposes a functional approach to imagery whereby images facilitate the retrieval of information from complex events in memory. The nature of the cue word in terms of its imageability is thus an important determinant in initiating retrieval cycles and directing memory searches.

Early work on the role of imagery in memory focused on the importance of concrete vs abstract materials or on the role of organizational factors in memory Paivio (1968, 1971, 1986). More recently De Beni & Pazzaglia (1995) considered memory for different kinds of mental images, focusing specifically on the role of contextual and autobiographical variables. They asked normal subjects to visualise a series of items and measured how quickly the subjects could form the images, how well they could later recall the images, and they also assessed subjective ratings of image quality. The items were visualised in isolation or in a specific context (general, episodic and autobiographical).

De Beni et al (1995) were particularly interested in the possibility that images of one's own life experiences have a special status in memory and in the fact that such images took the most time to generate, were recalled very well, and were very vivid. They identified three different categories of images; general, specific and autobiographic. A general image represents a concept without any reference to a particular example of it (*e.g houses).* A specific image represents a single well defined example of a concept without reference to a specific episode, (*e.g. looking at houses when we first moved to Wales).* An episodic autobiographic image represents the occurrence of a single episode in the subjects life connected to the concept (e.g. *the first time I saw the house in*

Wales that we subsequently bought). The latter two distinctions reflect specific and general autobiographical memories.

An analogous categorisation was proposed by Kosslyn (1994) who distinguishes between prototypical and exemplar images, considering autobiographical images a special case of exemplar images. This work is of interest to our investigation into the specific-generic distinction in autobiographical memories. Conway (1993) has previously raised the possibility that event specific knowledge represents a distinct independent pool of memories and work by Kosslyn (1994) has suggested that the right hemisphere is primarily concerned with the production of prototypical categorical images and the left hemisphere with specific exemplars.

It has long been known that visual images of more complex objects require more time to generate with an additional increment of time for each additional component (Kosslyn 1987). Work by Kosslyn (1994) distinguished between these two processes, defining them as categorical and co-ordinate spatial relations representations. Categorical spatial relations specify an equivalence class such as 'connected' to 'left of' or 'above'. Metric co-ordinate representations of spatial relations are critical for guiding movements, for example in navigational tasks where distances and exact locations are important.

Kosslyn (1987, 1994) also argued that prototypical representations of shapes are most naturally associated with categorical spatial relations and exemplar representations of shapes are most naturally associated with co-ordinate relations. For example when one is navigating in the dark (and hence relying on memory as a guide) one needs to know more than the precise distance of a table from the wall; one needs to know that particular table's shape and how it juts into the room. If each kind of spatial relations representation typically is stored with a particular kind of shape representation, then the right hemisphere might be better at representing prototypical shapes whereas the left might be better at representing specific exemplars. Presenting stimuli in grid form or enclosed in brackets to participant's left or right visual field and examining their reaction time for later identification provided strong support for the differential formation of images by the left and right hemisphere.

Autobiographical images are regarded by Kosslyn (1994) as a special case of exemplar images. The question arises thus whether the right hemisphere also plays a special role in the generation of general autobiographical images? The study of image generation by Kosslyn (1987, 1994) and by De Beni & Pazzaglia (1995) provides empirical evidence in support of different kinds of mental imagery reflecting different types of autobiographical memories. Different kinds of images (specific or general autobiographical images) characterised by different generation processes might have different localisation's in the brain. These issues raised by DeBeni & Pazzaglia (1995) agree with neurological and neuropsychological research data that showed a greater involvement of the right hemisphere in autobiographical and general image formation (Swartz 1984) and also the left hemisphere in more detailed images such as the specific and contextualised autobiographical images. While imagery research has provided empirical evidence for the role of autobiographical variables such as specific and general images in differentiating between different types of mental images, manipulating imagery variables by using high and low imageable cue words can also be used to manipulate retrieval from autobiographical memory.

However, the nature of the cue words used in autobiographical memory tasks have not been systematically investigated in terms of manipulating imagery and examining its effect on the specificity of subsequent recall of autobiographical memories. This thesis aims to examine this process by using high and low imageable cues to initiate preferential retrieval of either general or specific memories. The functional role of imagery in autobiographical memory with particular reference to the production of specific and general memories is investigated in four experiments. The first experiment investigates this association using an orthogonal design of cue words that are high and low in imageability and high and low in frequency. Using low imageability cues aims to replicate the findings from clinical studies where subjects tend to produce general memories spontaneously. The second study investigates the effects of different imagery modalities on autobiographical recall , examining the role of olfactory, tactile, motor, visual and auditory cue variables on vividness, pleasantness, frequency of rehearsal and specificity of memory.

An experimental manipulation of retrieval style is examined in experiment 3 and subjects instructed to recall specific events or summaries of events from their past. Using high and low imageable words to cue memories and allowing subjects to free recall in terms of autobiographical retrieval attempts to show that induction of a generic retrieval style reduces the specificity of images for the future. This finding is analogous to that shown in a clinical context where suicidal patients showed significant associations between the specificity of a memory and the specificity with which a future event could be imagined. Experiment 4 further explores the imagery variable and its power as a retrieval cue by obtaining measures of Predicability for each cue word used in the autobiographical memory tasks.

Chapter 4

The effects of frequency and imageability of cue words on Autobiographical Memory

Experiment 1.

The investigation of the structure, content and organization of autobiographical memory has revealed a number of dichotomies, reflected by distinctions between general summaries of past events and the formation of specific memories. These distinctions can be found using the classical cue-word paradigm, which was originally designed by Galton (1897) and subsequently developed by Crovitz & Schiffman (1974) and Robinson (1976). Further studies by Williams and colleagues (1986, 1988, 1992, 1994, 1996), Brittlebank et al (1992), Evans et al (1991) and Kuyken (1995) demonstrated similar findings of non specificity in clinical groups when the cue word paradigm was used. In assessing responses to such word cues, a distinction is made between memories of specific events (for example in response to a cue 'party' a specific response could be ' attending Dave and Sue's housewarming last Saturday night') and a general response which may reflect summaries of repeated occurrences (e.g. 'attending parties when I was at college').

Research with clinical groups has demonstrated an increase in the number of general memories recalled in a cue word autobiographical memory task, (Williams et al, 1986, 1988, 1992, 1994, 1996; Evans et al, 1990; Brittlebank et al; 1991; Kuyken 1995). Thus, non specificity in the recall of autobiographical memories has been a robust and replicable finding both in depressed and suicidal clinical groups. Overgenerality in autobiographical recall in elderly groups has been significantly correlated with reduced capacity to comprehend and to recall a text passage suggesting that working memory is implicated in the underlying mechanism (Holland and Rabbitt, 1991). Patients with post-traumatic stress disorder also experience difficulty retrieving specific autobiographical memories (McNally 1994). The inability to retrieve specific memories has implications for the treatment of these conditions and may indeed contribute to the maintenance of the emotional disorder (Williams 1992).

The primary aim of this experiment was to explore the mechanisms by which general and specific memories are formed in response to a range of cue words. While considerable empirical work has been undertaken in clinical groups, identifying memory deficits in the retrieval of specific autobiographical memories with groups of elderly, depressed and suicidal subjects, the mechanisms underlying such retrieval in a normal group of subjects has not been fully explored. Both encoding and retrieval dysfunctions have been implicated as possible mechanisms involved in the formation of overgeneral memories (Williams 1992).

One possibility is that emotionally disturbed subjects tend to preferentially encode affective aspects of a situation which occurs at a more general level. Over time further intermediate descriptions containing general summarised accounts of events that are highly emotionally self relevant are developed. Alternatively the formation of specific memories may simply be too effortful and difficult for depressed people either at the stage of encoding or retrieval or both. Control subjects however also show variation in the time taken to generate a specific memory. Understanding how normal people generate general and specific memories may inform and provide additional insights upon the clinical findings.

Previous studies of autobiographical memory have used a mixture of positive, negative and neutral words to evoke specific memories. This experiment focuses on other characteristics of cue words which may affect the specificity of memory response, namely the frequency and imageability of cues. The standard autobiographical memory task is altered in that only neutral cue words are used and the parameters of those words examined for their effects on the nature of memory responses. Schwanenflugel and Shoben (1983) and Wattenmaker and Shoben (1987) suggest that concrete and abstract words (high imageability and low imageability) are differentially represented in memory and that more information is stored about abstract concepts in a network.

In support of this, Schwanenflugel et al (1983) and Wattenmaker et al (1987) point out that abstract concepts are rated as occurring in a greater variety of contexts than do concrete concepts and hence contain more information. An alternative opposing view suggests that nodes for abstract concepts or low imageable words contain less information than those for concrete concepts (Kieras 1978). This theory assumes that the 'denser' representations of concrete concepts contain one or more links that are stronger than any of the links in the less dense representation of abstract concepts.

The process of retrieving information along links in a memory network should be affected by the internal structure of those representations. de Groot (1989) using a word association task, showed that word imageability exerts a strong influence on word association while the effect of word frequency was not significant. The effect of word imageability and word frequency on 'm' scores were also measured. An 'm' score is a measure of the number of responses generated within a pre-specified amount of time in a continued word association task (Noble 1952). Larger 'm' scores were obtained for concrete words than for abstract words suggesting that the concept nodes for concrete words contain more information than those of abstract words (de Groot 1989).

The relationship between specificity in autobiographical memory and this aspect of the cue word task has not been explicitly investigated. Although Williams & Dritschel (1988) found a positive correlation between the imageability of cue words and the specificity of memories retrieved, this was a post hoc finding as part of a larger study. Brewer (1986) suggests that recollecting autobiographical memories almost always involves visual imagery. Conway (1990a) using an image generation task showed thatautobiographical memories and generic images were judged to be higher in vividness than semantic images. In Conway's study participants rated whether the image they had generated had been a semantic image, a generic image or an autobiographical memory. There is sufficient empirical evidence to suggest a close association between imagery and the recall of autobiographical memories. It is predicted that to recall specific autobiographical memories should be easier and faster to high imageable words than for low imageable cues.

Apart from the primary aim of this experiment which is to investigate the retrieval of specific memories in response to high and low imageable cue words, a secondary aim is to examine the relationship between verabl IQ and specificity in autobiographical memory. Whether verbal IQ affects ability to recall specific memories has not previously been investigated using the cue word paradigm. Therefore a measure of verbal IQ (Spot the Word) was included in this experiment. The Spot the Word test serves as a measure of intelligence and general knowledge for words, and is regarded as the non spoken equivalent of the NART score (National Adult Reading Test) routinely used with clinical subjects.

Finally a third aim in this study was to investigate the association between text recall and specificity in autobiographical memory. Holland and Rabbitt (1990) investigating text recall and autobiographical memory, in an elderly group found that subjects who recall a text passage in detail also recalled autobiographical memories in more detail. Therefore the Weschler logical memory test was used in this study to explore any possible relationship between retrieval style or specificity in autobiographical memory and recall of a text passage.

Method

Subjects: Twenty four participants consisting of 20 females and four males were recruited from the Undergraduate Subject Panel of the University of Wales, Department of Psychology. The mean age of subjects was 30 years (SD, 9.4, range 21-48 years)

Autobiographical Memory Task. In this task subjects were required to recall events from their past in response to cue words. The time period from which events could be recalled was not specified and subjects were told that the events could be important or trivial. It was emphasised that the events from the past should be specific (i.e. events that had lasted less than a day). The time taken to recall such events was recorded using a stop watch and subjects given 30 seconds in each trial to retrieve a specific personal memory in response to a cue word. If subjects did not respond in the time available, a time of 30 seconds was recorded and the next cue word presented. All responses were taped and transcribed by the experimenter.

The test materials consisted of a corpus of 32 cue words consisting of nouns selected from Paivio's corpus of 925 nouns from which high and low imageability ratings were taken. Thorndike Lorge frequency ratings for these same nouns were also obtained from the Paivio corpus and Frequency ratings for the same words taken from Kucera Frances ratings; (these ratings are included in Appendix B). Word imageability (high vs low) and word frequency (high vs low) were orthogonally varied in this design. Each of the four stimulus groups constituted by the two levels of each of these two variables (imageability and frequency) consisted of 8 words. These word lists are shown in Table 4.

Table 4. 1

Cue words used in the autobiographical memory task

Group 1 High Imag. High. Freq.	Group 2 Low Imag. Low Freq.	Group 3 Low Imag. High Freq.	Group 4 High Imag. Low Freq.
Letter	Boredom	Duty	Bouquet
Grass	Explanation	Opportunity	Poetry
Library	Hearing	Law	Errand
Lake	Mood	Knowledge	Cradle
Factory	Obedience	Effort	Photograph
Teacher	Legislation	Interest	Nun
Sea	Upkeep	Situation	Spinach
Baby	Permission	Soul	Robbery

Key: High Imag= high imageability, Low Imag. = low imageability, High Freq. = high frequency, Low Freq. = low frequency.

The mean imageability rating of the words in the High Imag-High Freq., Low Imag-Low Freq., High Imag-Low Freq., Low Imag-High Freq. condition were 6.40 (SD=0.37), 3.30 (SD=0.38), 5.84 (SD.=0.96) and 3.30 (SD.=0.38) respectively. The mean Kucera Francis frequency ratings of the words in these groups were 98.5 (SD = 76.14), 32.75 (SD = 21.52), 19.40 (SD = 29.9) and 224.87 (SD = 126.28) respectively. The TLF for these same words were AA for high frequency words and the mean rating for low frequency cues was 117.0 and 124.0

Weschler Logical Memory Task; This task is a measure of verbal short term memory in terms of immediate and delayed recall (Wilson, Cockburn & Baddeley 1985). A short detailed structured story is read aloud to subjects who are then required to recall the story immediately and after a 30 minute delay.

Spot the Word task; This task is a measure of general knowledge for words and acts as a measure of verbal intelligence (Baddeley, Emslie & Nimmo-Smith 1993). The task consists of 60 pairs of items. Each pair consists of one genuine word and one false word which is specifically designed to be pronounceable and to have a plausible orthographical structure. Subjects were required to identify the real word and to respond to each pair guessing if necessary. Performance is scored in terms of the number of correct responses.

Procedure:

All participants performed the Weschler short story logical memory task at the beginning of the experiment. The structured passage was read out and immediate recall of this story was then tested. Subjects were scored according to the number of factually correct statements they recalled. Delayed recall of the story was tested approximately 30 minutes later at the end of the other experiments. Participants also performed the Spot the Word task and when presented with 60 pairs of items were requested to identify the real word in each pair. Performance was scored in terms of the number of correct responses.

Autobiographical Memory Task. Participants were required to recall events in response to cues. The following instructions were given;

> " I am interested in your memory for events that have happened in your life. I am going to read out a number of words. For each one, I want you to remember an event from your life that the word reminds you of. The event can have occurred at any time in your life and may be trivial or important. However the event should be a specific event and have occurred on a particular occasion. For example in response to a word party you could respond with "going to my first party last Monday in the Students Union" .

The presentation of each cue word was counterbalanced. Latency times were recorded immediately the cue word was called.If no response was made after 30 seconds, a time of 30 seconds was recorded and the next item presented. Following Baddeley and Wilson (1986), ratings of responses were converted into a scale of specificity in which a specific response scored 3 points, an intermediate response scored 2 points, a general response 1 point and omissions scored 0. [1] Following completion of this task, subjects were then requested to rate their memories for vividness, memory specificity,

---

[1] The main dependent variable of interest in this study was the the specificity of responses given to cue words. Although Williams & Dritschel (1992) distinguished between categoric and extended general memories, they found that extended memories were not affected by depression. All studies (see Williams 1996) have mainly focused on the level of specificity and this procedure is followed here.

whether the memory was pleasant or unpleasant , and to approximately date when the event occurred. For the ratings of vividness, subjects were instructed to assess how vivid their memory was by checking a number on a 5 point scale ranging from 1 (not at all vivid) to 5 (extremely vivid). A 5 point scale ranging from (1) unpleasant to (5) extremely pleasant was also used for pleasantness ratings. For specificity ratings, a 5-point scale ranging from (1) a vague and general memory to (5) a highly specific and detailed memory was also used.

Results

For each subject, the mean specificity score given in response to the cue words was calculated for the four conditions formed by the two levels of each of the variables Imageability (High Imag. vs Low Imag.) and Frequency (High Freq. vs Low Freq.). A 2 (imageability) X 2 (frequency) X subjects analysis of variance (ANOVA) was performed on the mean memory specificity scores treating imageability and frequency as within subject variables.

The corresponding 2 x 2 X 8 (stimulus words) ANOVA was also performed on the mean specificity scores, treating imageability and frequency as between subject variables. ANOVAS were computed for response omissions and also the mean retrieval or latency time to respond to cues per subject and per stimulus word.

Memory Specificity.

The means and standard deviations of specificity scores are shown in Table 4.2 and Figure 4.1. A main effect of imageability was significant on both the memory specificity analyses (F(a) subject analysis and F (b) item analysis);

F (1,23) = 44.48, MSe =9.60, p < .001, and for item analysis, F (1,28) = 14.88, MSe = 2.00, p< .001. The mean specificity score of memories retrieved to high imageable words was 18.87 compared to a mean value of 14.64 for cue words low in imageability. There was neither a main effect of frequency in either analysis, F (item) (1,28) = 0.11,MSe = 2.0, p>.05, and for subject analysis, F(1,23) = 0.86, MSe = 8.81,p>.05. No significant interaction was found.

Mean Retrieval Times.

The means and standard deviations of the retrieval times are also shown in Table 4.2 and Figure 4.1. A main effect of imageability was again significant for the mean retrieval time to respond to stimulus cues for both subject and item analysis. F(a) subject analysis and F(b) item analysis. Fa (1,23) = 40.89, MSe = 11.51, p< .001, Fb (1,28) = 41.11, MSe = 3.83, p < .001). The mean retrieval time to respond to high imageable words was 6.70 seconds compared to 11.27 seconds for low imageable cues. The main effect of frequency was not significant, for item analysis, F(1,28) = 0.20,MSe =3.83, p>.05, and for subject analysis, F(1,23) = 0.5, MSe = 5.30, p >.05. No significant interaction was shown.

Table 4.2

Mean Retrieval Time (in seconds) and Mean Specificity Score for all Imageability x Frequency Conditions

	Imageability			
Imageability	High		Low	
Frequency	R.T.	S.S	R.T.	S.S.
High	6.67(1.9)	19.33 (2.5)	11.11(4.0)	14.75(4.0)
Low	7.00(2.3)	18.42 (2.2)	11.44(4.8)	14.54 (4.4)

R.T. refers to retrieval or latency time to recall the first word of an event S.S. refers to the mean specificity score of participant's responses. Std deviation in parenthesis.

Figure 4.1 demonstrates the memory specificity and mean retrieval time of the different cue words.

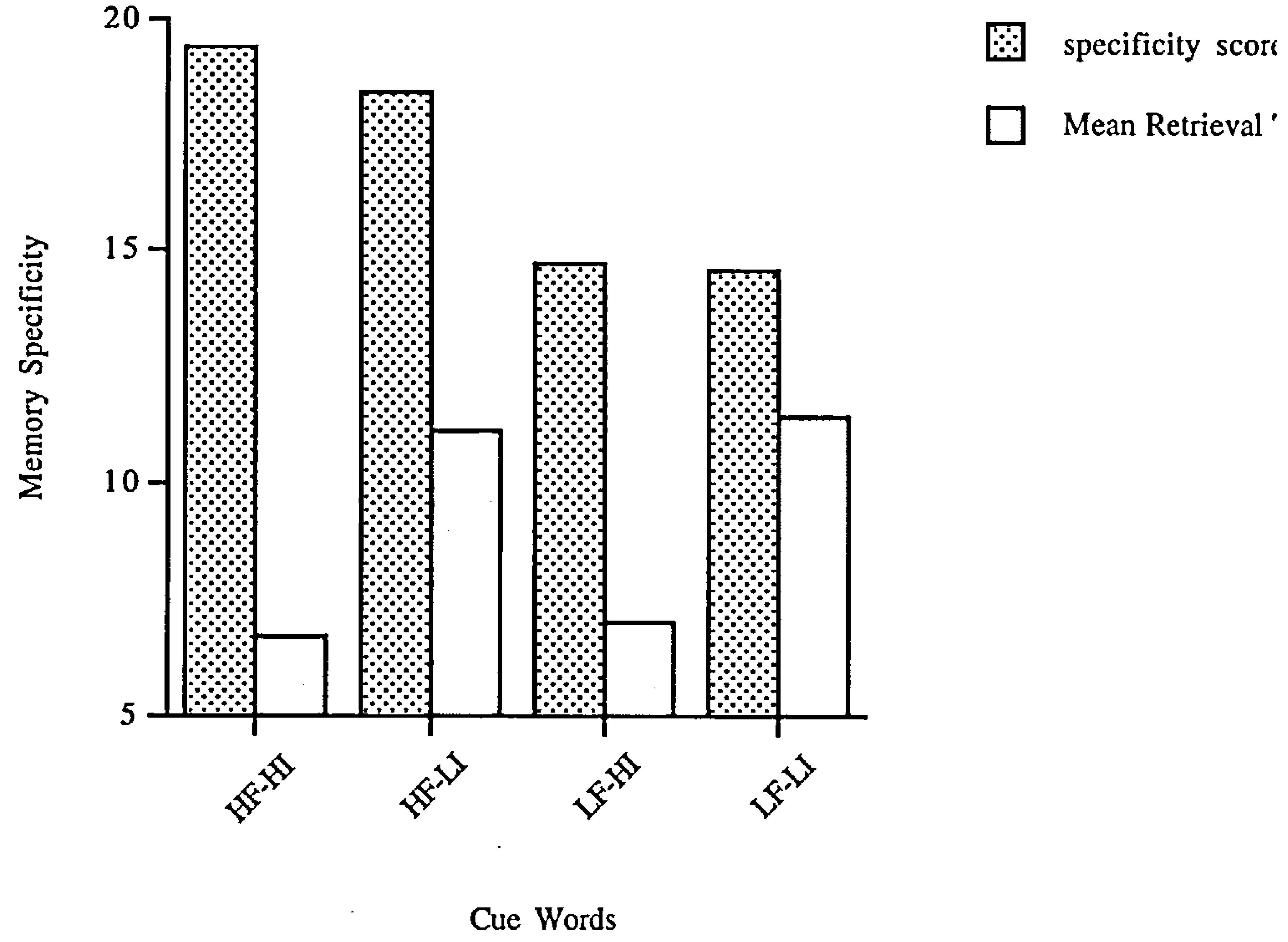

Figure 4.1. Memory Specificity and mean retrieval time of cue words

Omission Scores.

The omission scores where participants failed to respond to a particular cue word were analysed in a 2 (Frequency; high and low) x 2 (Imageability; high and low) Anova. The main effect of imageability was significant, F (subject) (1,23) = 11.52, p<.01, F (item) (1,28) = 16.40, p <.01,), due to the greater number of omission scores produced to Low Imag. stimuli (2.06) compared to those for High Imag. stimuli (0.38). No other main effects or interactions were significant.

Item Analysis.

Clark (1973) argued that in order to generalise from experiments using verbal materials, items should be treated as random effects rather than fixed effects.

The statistical treatment of language as a fixed effect was designated as a 'fallacy'. A consequence of Clark's position is that analyses of language experiments often require the use of statistical tests based on quasi F ratios (Winer 1971).

One way to assess the generality of findings from the present type of study is to calculate min F^1 ratios or to combine effects across experiments. Indeed Wike & Church (1976) recommend replications rather than item analyses as a way of generalising effects. Since the cues used in this experiment were selected randomly based on their imageability and frequency ratings they are treated as random effects. Thus, the results of the min F^1 ratios are calculated. Min F^1 ratios by item analyses for memory specificity and retrieval time showed that the effect of imageability remained significant; Min F^1 (1.44) = 11.11,p <.01, and for mean retrieval time; min F^1 (1,50) = 50.55, p <.001.

Weschler Short Story Recall

No significant differences were found between immediate and delayed short story recall (F(1,24) = 2.919; p=.10). The mean value of the immediate recall was 12.7 (3.2) and that of delayed recall was 11.7 (3.0). Normal values for this task are 9.76.(3.90) and 8.60 (4.06) respectively. Correlations between both immediate and delayed recall and memory specificity were not significant; (r (24) = .21, p >.05) and (r (24) = .19 p >.05) respectively.

Spot the word Test.

The mean score for this task across twenty four participants was 52.2 (s.d.= 7.4). No significant correlation was found between this measure and memory specificity (r (24) = .22, p > .05).

Ratings Scores. When participants had completed all tasks they were requested to rate the memories they had recalled in response to the cue words for vividness, pleasantness and how specific they judged the memories to be. The date of recalled memories was also requested. The mean values obtained for each cue type are shown in Table 4.3

Table 4.3

Ratings of vividness, pleasantness, and mean specificity for all Imageability x Frequency conditions

	Imageability					
	High			Low		
Frequency	Viv.	Pleas.	Spec.	Viv.	Pleas.	Spec.
High	4.1	3.5	3.9	3.8	3.0	3.3
Low	4.0	3.5	3.9	3.8	2.3	3.2

Viv. refers to mean vividness rating, Pleas. refers to mean pleasantness rating and Spec refers to mean subjective ratings of memory specificity.

Three 2 (imageability, high and low) x 2 (frequency, high and low) ANOVAs were computed on the mean subjective ratings of specificity, pleasantness, and memory vividness. Imageability and frequency were treated as within subject factors. For memory specificity there was a significant effect of imageability, $F(1,23) = 37.24$, $MSe = 0.27$, $p < .001$. Memories retrieved in response to high imageable cues were rated as significantly more specific ($M = 3.9$) than those retrieved to low imageable cues ($M = 3.2$). There was no main effect of frequency and the interaction was not significant. Similarly in the analysis of memory vividness, a significant main effect of imageability was shown, $F(1,23) = 10.21$, $MSe = 0.20$, $p < .01$. Autobiographical memories retrieved to high imageable cues were rated as significantly more vivid ($M = 4,1$) than memories retrieved to low imageable cues ($M = 3.8$).

Analysis of subjective ratings of memory pleasantness showed a significant main effect of frequency, $F(1,23) = 18.50$, $MSe = 0.15$, $p < .001$, and also a significant main effect of imageability, $F(1,23) = 88.72$, $MSe = 0.21$ $p < .001$. Significantly more pleasant memories were recalled in response to cues words high in imageability ($M = 3.5$) than to cues low in imageability ($M = 2.6$). Similarly significantly more pleasant memories were retrieved to high frequency cues ($M = 3.3$) than to low frequency cues ($M = 2.9$). Both these main effects were qualified by a significant interaction between cue imageability and frequency, $F(1,23) = 19.90$, $MSe = 0.16$, $p < .001$. Planned comparisons showed that memories retrieved to cues low in frequency and imageability were significantly less pleasant than those retrieved to the three other cue categories, ($p < .001$). Memories retrieved to HF-HI cues were significantly more pleasant than those retrieved to HF-LI, ($p < .001$), and no significant differences were shown between HF-HI cues and LF-HI cue words.

Age of Memories.

The ages of each specific memory recalled by all participants were standardised in the following way,(Conway & Bekerian 1987) The age of the memory in months (backdated from the time of recall) was divided by the total age of the participant (also in months) and the product then subtracted from 1. Thus each memory age was expressed as a number between 0 and 1 with a higher number indicating a more recent memory. This transformation has the advantage of expressing the age of a memory in terms of a proportion of a participant's life thus making the ages of memories for different age groups more comparable. The standardised memory ages were entered into an analysis of variance similar to that used for memory specificity, where imageability and frequency were treated as within subject factors. Main effects or interactions were not significant and there were no significant differences in the ages of memories retrieved to the different cue groups. The mean ages of memories retrieved for High Freq - High Imag, High Freq - Low Imag, Low Freq - High Imag, and Low Freq - Low Imag cues were recent memories with mean ages of 0.89, 0.83, 0.88 and 0.86 respectively.

Discussion.

Although previous studies had suggested that imagery may facilitate the retrieval of information from memory and that imagery may be an important mediator in the specificity of retrieval, no previous study has previously examined this question directly using a cue word paradigm. The aim of this experiment was to assess the effects of cue word imageability and word frequency on the retrieval of personal memories.

The results show that words high in imageability have a significant effect in mediating the retrieval of specific memories. Williams & Dritschel (1988) also demonstrated a positive correlation between the imageability of the cue word and the mean specificity of memories for both overdose patients and control subjects, suggesting that contextual cues which are distinctive, concrete and highly imageable are more successful at overcoming a 'categoric' retrieval cycle'. There was no significant effect of word frequency on the specificity of memory responses or on the mean memory retrieval time. Retrieval times for autobiographical memory recall are commonly very labile. However cue words high in imageability resulted in reduced retrieval times compared to low imageable cues. The ages of specific memories retrieved to the different cues were all relatively recent memories and no significant differences were found between the ages of memories retrieved to the different cue types.

This study can be compared with the results of an analogous investigation by de Groot (1989). She used a similar orthogonal design to assess the effects of word imageability and word frequency in word association. Her findings suggest that word imageability exerts a strong influence on word association whereas the effect of word frequency is negligibly small. High imageable words were associated to faster than abstract words, the association frequency of primary responses to high imageable words was larger and the reaction time smaller. de Groot also investigated the roles of word imageability and frequency on 'm' the number of responses generated to a stimulus word within a prespecified amount of time in continued word association. The larger 'm' scores obtained for concrete words than for abstract words 'have been taken to indicate that the concept nodes of high imageable words contain more information than those of abstract words' (de Groot 1989, p. 836). Such findings are also consistent with knowledge-based accounts of imagery effects (Kieras 1978).

This conclusion has implications for the results of the present study of autobiographical memory. The process of retrieval incorporating the cyclical retrieval strategy described by Williams & Hollan (1981) may be a more effortful process when low imageable cue words are used because such cues are unlikely to generate efficient descriptors that are useful in memory retrieval. The verification of the memory generated from the cued description may take longer, given that the task constraints are violated, equally there may be repeated successive cycles to find or construct a representation that satisfies the experimental constraints. Participants usually respond not having retrieved an event of the required specificity.

Unlike the referents of abstract words, the referents of concrete words have shapes, colors, physical parts and occur in spatial contiguity with other objects. When presented with a cue word and required to evoke a specific personal memory in response, the latter characteristics of highly imageable words facilitate the retrieval of specific event memories. Access to intermediate pathways in hierarchical frameworks of autobiographical memory is enhanced with context-rich cues.

For proponents of a network model of memory, two factors are regarded as particularly important determinants of information retrieval from the memory network; the strength and number of links departing from the stored concept nodes (Anderson 1976; Collins and Loftus 1969). The stronger the link between two concept nodes, the more activation it receives from the source and the easier it is to retrieve information along the link. Hence if concrete high imageable cues forge strong links forming descriptors, this should facilitate the retrieval of specific autobiographical memories.

Barsalou (1983) proposed that concepts contain two types of information, context independent, and context dependent. The former is defined as information that is activated each time the concept's name is encountered irrespective of the context in which it occurs. In contrast the activation of a context's dependent information depends upon the particular context in which it occurs. Schwanenflugel & Shoben (1983) suggests that concrete high imageable concepts contain both context independent and context dependent information whereas abstract low imageable words/concepts only contain mainly context dependent information.

According to this model, the typical finding that abstract sentences are not as easily comprehended as concrete sentences is due to the fact that people have greater difficulty determining appropriate contextual information for abstract material. While this model addressed language comprehension, similar processes operate in terms of 'context availability ' in word association tasks (de Groot 1989) and possibly in the retrieval of autobiographical memories in response to high and low imageable cues. In all cases, the basic process is retrieval along links in memory nodes. This would explain why attempting to retrieve a specific memory to a low imageable cue is a more effortful process if such cues are context bound. Fewer links are forged to access sufficient descriptors to generate a specific autobiographical memory. Furthermore, there were more omissions or errors produced to low imageable cues compared to high imageable cues, which would suggest that retrieval of specific autobiographical memories in such trials was an effortful process.

A secondary aim of this experiment was to examine whether a more general memory ability or IQ rating affected specificity of retrieval. Results showed that there were no significant correlations between text recall and specificity of autobiographical memory recall. This may be due to the nature of the text passage used. The Weschler logical short story passage, unlike the detailed structured text employed by Holland and Rabbitt (1990) is a brief script and primarily employed and designed to measure immediate and delayed short term memory in clinical groups. Thus the task may have been too easy for a non clinical group and too insensitive to detect variation in text recall. The measure of verbal intelligence included in this task is also designed to test clinical groups and may again have been too easy a task to measure differences in an undergraduate population.

The construction of autobiographical memories is a complex process, mediated by central processes which access a structured and layered knowledge base which in turn indexes sensory and perceptual event specific knowledge. The functional role of imagery in mediating and facilitating such processes is an important one and the results of this experiment suggest that imageability may mediate specificity in autobiographical memory. However, the study raises the question as to which imagery modality is responsible for these effects?

Visual imageability is the usual modality that is commonly assumed to mediate memory effects, the notion of 'seeing pictures with the mind's eye' being seen as typical for retrieving autobiographical memories where images of past events can be particularly vivid. Previous studies by Barsalou (1988) and Rubin & Kozin (1984) have found personal event memories to be highly associated with vividness. However imagery varies across a number of dimensions and incorporates other modalities such as olfactory, and tactile modes. The aim of the next study is to further investigate the effect of imagery and retrieval from autobiographical memory by examining other imagery modalities.

Chapter 5

Imagery Modality Effects and Autobiographical Memory

Experiment 2.

The results of the last experiment suggest that retrieval cues which are high in imageability may mediate the production of specific autobiographical memories. Cue words high in imageability resulted in the recall of more specific memories and the retrieval time taken to recall these memories was significantly faster than for other less imageable cues. Since imagery varies across a number of different dimensions or modalities, the question arises as to whether any particular form of imagery is more closely associated with the retrieval of specific autobiographical memories. The purpose of this experiment was to investigate the effects of different imagery modalities on autobiographical recall.

The generation and construction of autobiographical memories is a staged process and access to intermediate pathways and subsequent specific event memories is enhanced with context rich cues or by events which are high in imagery. The results of Experiment 1 suggest that impoverished or low imageable cues are poor at accessing specific event memories because insufficient meaningful associative links are forged to generate efficient retrieval cycles and the result is a truncated search. While visual imageability is assumed to be the most common imagery modality responsible for mediating memory effects in verbal learning paradigms and in refreshing and maintaining memories of past events, it is possible that other imagery modalities may also have a functional role in the retrieval of autobiographical memories.

Previous analyses of imagery have concentrated on the visual system and Paivio (1971) has suggested different explanations of visual imagery effects. These include the richness of representation afforded by the visual system, the parallel nature of the visual system and the possibility of the visual system utilising a number of different codes to process information. However highly imageable words are also likely to vary in unspecified ways on dimensions other than visual imageability. The effect of cue words reflecting different levels of imagery modalities (tactile, olfactory, auditory, motor, and visual) on retrieval of autobiographical memories are of particular interest in this experiment. The effects of imagery in verbal memory tasks may result from imageable words having richer representation as a result of their associations in different perceptual modalities and such enhanced representations may allow greater associative linkages with other items and consequently facilitate retrieval, or access to specific memories.

Although Baddeley & Hitch (1974) proposed only two slave systems (the visuo spatial sketch pad and the phonological loop) in their model of working memory, it was recognised that there may be other slave systems with specialised functions, for example tactile, kinaesthetic, or olfactory. There have been few attempts to gather evidence for such systems. The effects of different imagery systems on a range of verbal learning tasks was however investigated by Ellis (1991). Word norms for imageability in visual, auditory, motor, olfactory and touch modalities were derived and the effect of these factors on free recall and paired associate learning examined. Results showed that the only imagery dimension which predicted performance was visual imagery.

Previous studies have concentrated on how visual imagery mediates performance on a range of verbal learning tasks, the role of imagery across other modalities, (auditory, olfactory, tactile and motor) has not been investigated in an autobiographical memory task. Given the effects of imageability in verbal learning tasks and the results by Ellis (1991) discussed above, it was predicted that cues high in visual imagery may result in significantly more specific autobiographical memories being recalled.

Method

Subjects: Twenty-four participants participated in this experiment. They were all Psychology undergraduates. There were fifteen females and nine males. The mean age of the sample group was 23.6 years (SD = 6.13 years ; range 19-38 years)

Procedure

A cue word paradigm was employed to investigate the effects of words differing in imagery modality on autobiographical recall. Word norms for imageability in visual, auditory, olfactory, motor, and tactile modalities were taken from Ellis (1991). Five lists of words were prepared: words with high visual, auditory, motor ,olfactory or tactile associated activity together with a control set of abstract words with none of the above associations. From these initial lists, six words were selected from each list and an additional six abstract words having low ratings on all perceptual modalities. The six sets of words selected for this experiment were matched for frequency and the different sense modalities were as far as possible unassociated, with each individual word predominating in one sensory modality only. The imageability ratings of each word are listed in Appendix B. The lists of cues are shown in Table 5.1.

Table 5.1

Imagery modality

Visual	Olfactory	Tactile	Auditory	Motor	Abstract
Butterfly	Cheese	Ice	Choir	Spade	Wisdom
Cloud	Chlorine	Sponge	Laughter	Football	Worth
Fire	Rose	Needle	Snore	Axe	Moral
Painting	Coffee	Can-opener	Thunder	Racquet	Attitude
Mountain	Smoke	Wool	Cry	Pump	Greed
House	Curry	Satin	Whistle	Hammer	Thought

The mean modality ratings for the cues used are included in Table 5.2

Table 5.2

Mean modality ratings for word norms

Modality	Vis.	Olf.	Tac.	Aud.	Mot.
Visual	**5.80**	1.98	2.71	1.77	4.0
Olfactory	4.36	**5.40**	2.80	1.15	2.78
Tactile	4.36	1.62	**4.96**	1.66	3.20
Auditory	2.30	1.02	1.52	**6.11**	4.22
Motor	4.16	1.44	4.40	3.70	**4.94**
Abstract	1.29	1.00	1.26	1.17	1.98

Vis = visual imagery, Olf = olfactory imagery, Tac = tactile imagery, Aud = auditory imagery Mot = motor imagery.

Each participant was presented with 36 cue words reflecting different word imagery modalities. The presentation of cue words was counterbalanced across all autobiographical memory trials. Subjects were requested to recall a specific memory or event in response to the cue word and the time taken to retrieve a memory recorded using a stopwatch. The following instructions were given;

" I am interested in your memory for events that have happened in your life. I am going to read out a number of words. For each one, I want you to remember an event from your life that the word reminds you of. The event can have occurred at any time in your life and may be trivial or important. However the event should be a specific event and have occurred on a particular occasion. For example in response to a word 'party' you could respond with "going to my first party last Monday in the Students Union". It is important to try and respond to each word"

All participants were given practice trials to ensure familiarity with the task. On completion of the cue word task, subjects were requested to rate their memories for vividness, frequency of memory recall (how often they have recalled this event) and pleasantness. Participants were also requested to rate their memories for specificity and to date the event they had recalled.

For the ratings of vividness, subjects were instructed to assess how vivid their memory was by checking a number on a 5 point scale ranging from (1) not at all vivid to (5) extremely vivid). A 5 point scale ranging from (1) unpleasant to (5) extremely pleasant was also used for pleasantness ratings. For specificity ratings a 5-point scale ranging from (1) a vague and general memory to (5) a highly specific and detailed memory was used. Frequency of recall ratings were divided into a 3-point scale where subjects were given three choices; whether the memory was frequently recalled (1), occasionally (2) and never before (3).

Results

The mean memory specificity scores and mean retrieval time were analysed by subject and by item. Rating scale scores by participants were also analysed. The results are reported in two sections. The first section reports analyses on retrieval times, memory specificity, and ratings, while the second section reports a multiple regression analyses of these variables

Memory Specificity.

Following Baddeley and Wilson (1986), ratings of responses were converted into a scale of specificity in which a specific response scored 3 points, an intermediate response scored 2 points, a general response 1 point and omissions scored 0. The means and standard deviations of memory specificity for each cue and retrieval time are shown in Figure 5. 1 and Table 5.3. An item analysis of variance was performed where sensory modality was treated as a between subject variable and memory specificity as a dependent variable. The modality factor had 6 levels; visual, olfactory, auditory, tactile, motor and abstract. A subject analysis of variance was also computed, where sensory modality was treated as a within subject variable. Similar Anovas were computed for mean retrieval time.

Results show a significant effect of imagery modality on memory specificity with both subject and item analyses. F (item) $(5,30) = 7.95$, $MSe = 0.04$, $p<.001$, F (subject) $(5,23) = 27.67$, $MSe = 30.31$, $p <.001$. More specific memories were retrieved to cue words high in imageability than the low imageable abstract cues. Post hoc Newman-Keuls tests on item analysis ($p <.05$) demonstrated significant differences between abstract words (those not associated with any sensory modality) and the other cue words (visual, tactile, olfactory, motor and auditory). There were significantly less specific memories recalled to abstract cues. There were no significant differences in the specificity of memories retrieved to visual, tactile, olfactory, motor and auditory cue words.

Retrieval Time

The mean retrieval times for each category of cues are shown in Table 5.3 and Figure 5.1. A significant effect of modality was shown in both item and subject analysis, F (item) $(5,30) = 12.22$, $MSe = 1.81$, $p < .001$, and F (subject) $(5,23) = 13.86$, $MSe = 45.15$, $p < .001$. Abstract words produced the longest retrieval times and post hoc comparisons (Neuman Keuls) demonstrated significant differences between abstract words and the remaining modalities, ($p < .01$). There were no significant differences in terms of retrieval time between these cues (visual, tactile, motor, olfactory, and auditory).

Min F^1 ratios were calculated for memory specificity, Min F^1 $(5,44) = 6.16$, $p < .01$, and for mean retrieval time, min F^1 $(5,53) = 6.50$, $p < .01$), showing a significant effect of imageability for both dependent variables, (specificity in autobiographical memory and mean retrieval time).

Table 5.3

Mean Specificity of Memories and Mean Retrieval Time

Word Modality	N	Specificity	Retrieval Time
Visual	6	15.37 (2.44)	6.20 (2.76)
Olfactory	6	13.79 (2.87)	8.28 (3.69)
Tactile	6	13.54 (3.23)	9.79 (4.16)
Auditory	6	15.16 (2.23)	8.42 (2.56)
Motor	6	14.37 (3.43)	9.41 (3.30)
Abstract	6	9.12 (3.40)	12.78 (4.32)

Maximum Specificity Score = 18

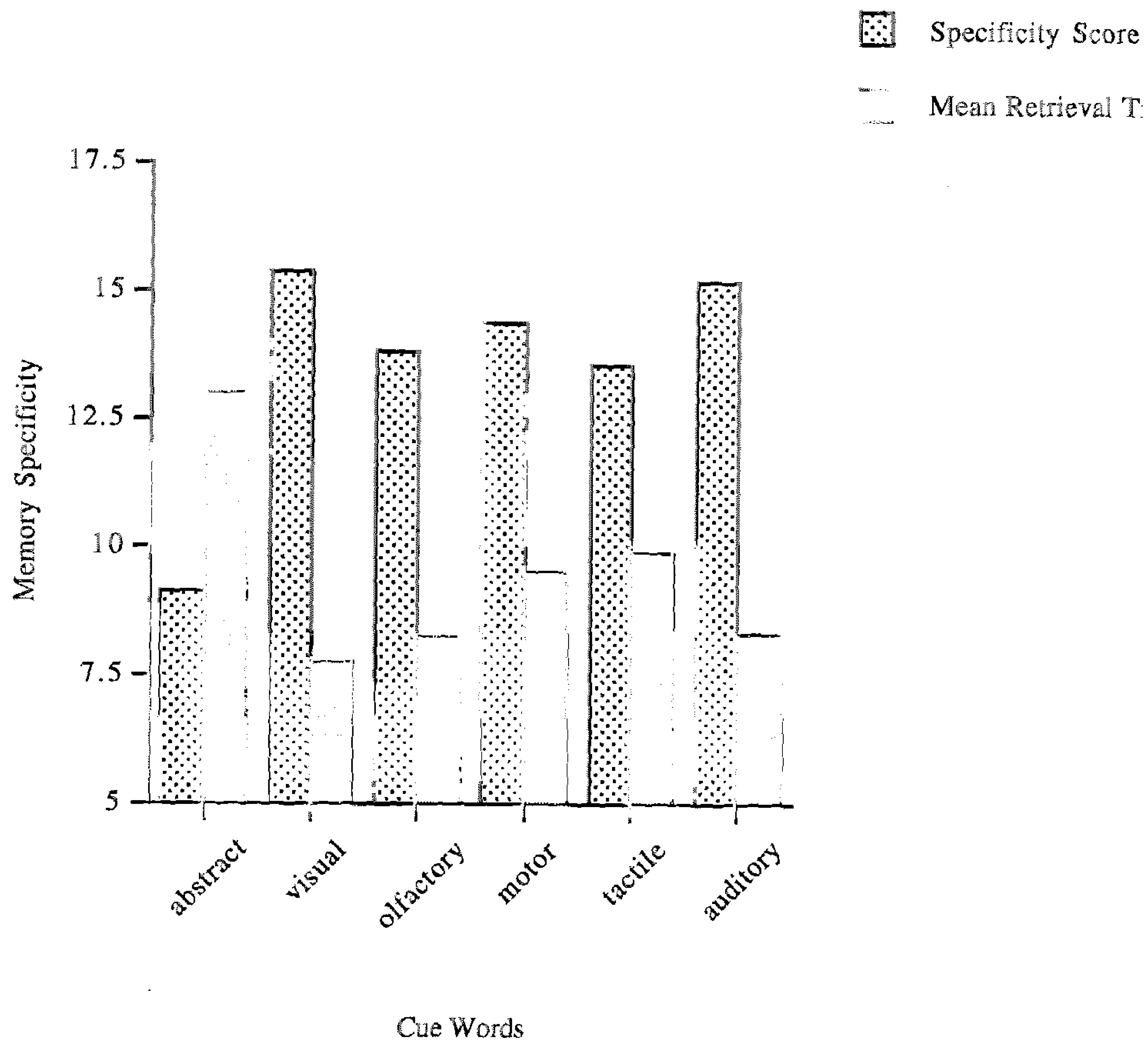

Figure 5.1. Mean Specificity and Retrieval Time for each cue modality

Memory Ratings

Memories were rated for pleasantness, vividness, and frequency of recall. The means of those memory ratings are shown in Table 5.4

Table 5.4

Mean Memory Ratings for Word Modalities

Rating Scale	Vis.	Olf.	Tac.	Aud.	Mot.	Abstract
Pleasantness	3.90	3.18	3.31	3.20	3.11	2.94
Vividness	4.25	4.22	4.12	4.08	3.79	3.59
Rehearsal	2.01	2.33	2.39	2.21	2.37	2.18
Specificity	4.24	4.19	4.08	4.16	3.87	3.42

Note. Vis.=visual imageability, Olf.= olactory imageability, Tac = tactile imageability, Aud.= auditory imageability, Mot. = motor imageability. Ratings range from 1-5 for pleasantness, vividness and specificity and from 1-3 for frequency of rehearsal

Four one way analyses of variance were conducted on each of the rating scales separately treating modality as a between subject factor. Newman Keuls post hoc tests were computed for all significant effects.

Ratings of Pleasantness: A significant effect of word modality was found for this measure F (5.30) = 2.76, $MSe = 0.23$, $p<.05$. Post hoc tests ($p<.05$) showed that ratings of pleasantness of memories retrieved to cues high in visual imagery were significantly higher than memories retrieved in response to auditory, tactile, and abstract cues. There was no significant difference in the pleasantness of memories evoked to visual, motor or olfactory cue words.

Ratings of vividness. A significant effect of word modality was also found for vividness ratings $F(5,30) = 7.53$, $MSe = 0.05$, $p < .01$. Post hoc comparisons showed that memories retrieved to abstract cues were significantly less vivid than those retrieved in response to all other cue modalities. Significantly more vivid memories were also retrieved in response to auditory, olfactory and visual cues compared to motor cues. There was no difference in the vividness of memories retrieved tactile or motor cues. Similarly the differences in memory vividness of responses to auditory, olfactory, visual and tactile cue words did not reach significance.

Ratings of frequency of rehearsal: A significant effect of word modality was shown $F(5,30) = 2.76$, $MSe = 0.3$, $p < 05$. Significant differences ($p<.05$) were found between the ratings of frequency of rehearsal for memories retrieved to visual word cues and cue words high in motor and tactile imagery. Memories retrieved in response to the latter cues were less frequently recalled.There were no significant differences in how frequently participants recalled memories retrieved to cues high in visual, olfactory and auditory imageability and in addition to the abstract cues.

Ratings of Specificity: Analysis of subject's ratings of memory specificity showed a significant effect of modality $F(5,30) = 7.74$, $p < .01$. It was found that ratings of specificity for abstract memories were significantly less than for memories retrieved to the other cue words ($p<.05$). There was no significant difference in subjective ratings of specificity for memories retrieved to the remaining cue modalities.

In summary memories retrieved to cue words high in visual motor and olfactory imageability resulted in the recall of events that were significantly more pleasant than memories retrieved to the other cue modalities. There were no significant difference in the vividness of memories retrieved to visual, auditory, olfactory and tactile cues. Ratings of vividness showed that memories retrieved to abstract and motor cues were significantly less vivid than for the other modalities.

Subjective ratings of specificity were consistent with independent ratings of memory specificity. Memories retrieved to abstract cue words were rated as being significantly less specific than those retrieved to all the remaining cue modalities. Consistent with the independent ratings of memory specificity when subjects rated their own memories for specificity, no significant differences were shown between auditory, visual, tactile, motor and olfactory cues.

Age of Memories.

The ages of each memory recalled by all participants were standardised in the same way as in the previous experiment. The age of the memory in months (backdated from the time of recall) was divided by the total age of the participant (also in months) and the product then subtracted from 1. Thus each memory age was expressed as a number between 0 and 1 with a higher number indicating a more recent memory. This transformation has the advantage of expressing the age of a memory in terms of a proportion of a participant's life thus making the ages of memories for different age groups more comparable. The standardised memory ages were entered into an analysis of variance similar to that used for memory specificity. There were no significant effects observed ($F(5,30) = 1.69$, $MSe = 0.01$, $p > .05$.) and the memory ages retrieved across the different sensory modality categories were very similar. All the memories were very recent memories with mean ages as follows (visual 0.90; olfactory 0.83; tactile 0.83; auditory 0.83; motor 0.85 and abstract 0.90).

Correlation Analyses.

A correlation matrix was computed including all the independent variables, and dependent variables of memory specificity, mean retrieval times and the different memory rating scales. This matrix is shown in Table 5.5. Memory specificity correlated significantly with cue words high in visual imagery, ($r(36) = .53$, $p < .01$), motor imagery ($r(36) = .49$, $p < .01$).

A negative significant correlation ($r(36) = -0.67$, $p < .001$) was shown between memory specificity and the mean latency to retrieve a specific memory replicating the results of experiment 1. Cue words high in visual imageability also correlated significantly with ratings for mean pleasantness and mean vividness ($r(36) = .40$, $p < .01$) and ($r(36) = .52$, $p < .01$) respectively.

Table 5.5

Correlation Matrix Showing Relationships between all Variables

	Vis.	Aud.	Tac.	Mot.	Olf.	Freq.	MRT	Spec.	MV.	MP.	MF
Vis.	1.00	-0.29	**0.52**	0.30	**0.54**	0.07	**-0.59**	**0.53**	**0.52**	**0.40**	0.00
Aud.		1.00	-0.12	**0.59**	-0.36	-0.12	-0.34	0.23	-0.13	0.16	0.12
Tac.			1.00	0.30	0.26	-0.31	-0.22	0.12	0.16	0.16	0.42
Mot.				1.00	-0.18	-0.17	**-0.54**	**0.49**	0.18	0.10	0.03
Olf.					1.00	0.08	-0.26	0.24	0.36	0.05	0.20
Freq.						1.00	0.06	0.09	0.24	0.14	-0.36
Mrt.							1.00	**-0.67**	**-0.57**	-0.23	0.14
Spec.								1.00	**0.86**	0.11	-0.11
MV.									1.00	**0.47**	-0.29
MP.										1.00	-0.39
MF.											1.00

Note - Vis= visual, Mot= motor, Tac= tactile, Olf = olfactory, Aud. = auditory, Freq = frequency, Mrt = mean retrieval time, Spec= specificity, MV = mean vividness, M.P. = mean pleasantness, M.F. = mean frequency of rehearsal, sig., correlations in bold ($p < .01$)

Multiple regression analyses were performed on the dependent variables, memory specificity and mean retrieval time, in order to determine the contributions of different imagery modalities to the variance associated with specificity in autobiographical memory. The independent variables included were the 5 sensory modality (visual, auditory, tactile, motor, and olfactory) ratings calculated for the word norms.

For memory specificity when all the predictor variables were entered into the equation simultaneously, the only significant predictor was visual imagery rating (ß = 0.59, p<.01). This predictor accounted for 51% of the variance. A stepwise regression using the same variables as above stopped after 2 blocks when the only significant predictors entered were visual imagery and auditory imagery (ß= 0.66, p<.01 for Visual Imageability, and (ß= 0.43, p<.01 for Auditory Imageability). See Tables 5.6 and 5.7.

Table 5.6

Summary of Multiple Regression with all variables entered simultaneously

R = 0.62, F (7,28) = 6,57; p = .0026

Variable	B	SEB	ß	R^2
Visual I.	1.47	.58	.59	.51

The results of a stepwise multiple regression on memory specificity as the dependent variable are shown in Table 5.7. This equation stopped after the addition of two variables. Visual imageability contributes 28% of the variance and auditory imagery 17% of the variance in memory specificity at the second step of this model.

Table 5.7

Summary of Stepwise Regression Analysis for variables predicting specificity in the retrieval of autobiographical memories (N = 36)

Variable	B	SEB	ß	R^2
Step 1				
Visual I.	1.32	0.36	0.53	.28
Step 2.				
Visual I.	1.64	0.33	0.66	.45
Auditory I	0.94	0.29	0.43	

Note. R Square =..28 for Step 1; change in R^2 = .17 for Step 2 (p<.001)

Mean Retrieval Time.

The same multiple regression analyses were performed for mean retrieval times as the dependent variable and the results of the stepwise regression model are shown in Table 5.8. Visual imagery was a significant predictor (ß= -0.67, p<.01) and also auditory imagery (ß = -.44 p <.05, with both contributing 62% of the variance in the equation when all predictors were entered simultaneously. A stepwise regression model was constructed, which enters the predictor variables into the equation individually. This equation stopped after two blocks with the only significant predictors again being Visual Imageability and Auditory Imageability.

Table 5.8

Summary of Stepwise Regression Analysis for variables predicting speed of retrieval time in the retrieval of autobiographical memories (N = 36)

Variable	B	SEB	ß	R^2
Step 1				
Visual I.	-0.75	0.17	-0.59	.35
Step 2				
Auditory I.	-0.54	0.13	-0.49	.57
Visual I.	-0.93	0.15	-0.73	

Note. R square = .35 for step 1, change in R^2 = ..22 for step 2.

The results of the multiple regression suggest that visual imagery and auditory imagery are the only sensory modalities which contribute significantly to the variance in both dependent variables, (specificity, and speed of retrieval in autobiographical memory).

Discussion.

Experiment 1 showed that participants found it more difficult to retrieve a specific memory in response to a low imageable cue word. Highly imageable cues appeared to facilitate access to specific memories. However it remained unclear which sensory modality mediated this effect. The current experiment examined the contributions of a number of different sense modalities to the retrieval of specific autobiographical memories.

The results of this experiment showed that there was no significant difference in the specificity of autobiographical memories retrieved in response to visual, olfactory, motor, tactile or auditory modality cues. Equally there was no significant difference in the time taken to retrieve an autobiographical memory between these different perceptual cues. Memory ratings showed that while memories retrieved to visual cues were significantly more pleasant than those retrieved to tactile, auditory and abstract cues, no significant difference in pleasantness was shown in those memories retrieved to visual, motor or olfactory cues. Similarly no significant differences in memory vividness were demonstrated between memories evoked to the different imagery modalities.

Memories retrieved to abstract cues however were significantly less vivid and less specific than memories retrieved to visual, tactile, olfactory, motor or auditory cues. In terms of memory specificity no significant differences were shown between the latter cues. Multiple regression analyses showed however that both visual and auditory imageability were significant predictor variables with regard to memory specificity and mean retrieval time.

Thus, the effect of the different imagery modalities (tactile, visual, olfactory, motor, auditory) on the recall of autobiographical memories suggest that visual imageability was the greatest contributor to both memory specificity and mean retrieval time along with a smaller effect of auditory imagery. It is the extent to which a cue is high in visual imageability, that predicts speed and directness of access to those specific event memories embedded within the memory network.

Ellis (1991) investigated different sensory modalities for their effect in verbal learning tasks including free recall, and paired associative learning. The significant contribution of visual imageability across all such tasks, was attributed to both the visual parallelism and coding richness afforded by the visual system. The rich representations of items and cues mediated by visual imageability allows a greater number of associative meaningful linkages. Extending these findings to the case of autobiographical recall, visual imagery may enhance contextually rich retrieval cycles resulting in speedy access to specific memories. Visual parallelism implies that activation of the visual codes initiates activation in semantic, and episodic systems, resulting in widespread spreading activation of all possible inter-relations.

One of the most established findings from experimental studies is that imagery enhances memory performance for a variety of learned verbal materials (Paivio 1971, 1986, Richardson 1980). The type of explanation provided for such effects typically postulate a form of privileged encoding or dual coding. The mechanisms underlying these processes are however unclear. One way may be to provide some form of summary information or intermediate descriptions which could be used to direct memory search. Images might represent the most efficient form of such summary information which retrieval processes could use to search a memory trace. That is, they constitute the most economical way of representing information, since they represent configurations of features, that are easily accessible. In turn these configurations could assist in further iterations in the retrieval process.

An alternative account of imagery effects and the recall of specific autobiographical memories relies on the results of studies in verbal learning tasks. Visual imageability mediates more semantic associations, and the dual effects of coding richness and parallelism are present in both traditional verbal learning tasks and possibly in the more ecologically valid task of autobiographical memory recall. This interpretation of imagery effects in terms of inter-item relational processing rather than the retention of images in some modality specific form as suggested by Conway (1987) accords with recent theoretical developments by Marschark and Surian (1989).

Marschark et al (1989, 1991) suggest that the relational or distinctive elements in material for recall may be more important than whether material is concrete or abstract. By "distinctiveness", Marschark refers to the features of an item that make it readily discriminable from other items that are to be remembered, and by relational he refers to the extent to which an item for recall can be organized and integrated in memory. While this theory is concerned with memory for text passages, it may also be relevant for the power of retrieval cues, responsible for accessing and integrating specific autobiographical experiences.

Previous studies of patients with visual imagery impairments have not assessed deficits on autobiographical recall but there is now some evidence to support the hypothesis that recalling past autobiographical events requires intact visual imagery abilities. If visual imagery is such a significant factor in the formation of autobiographical memories, then patients with damage to those brain regions underlying imagery may show impairment in autobiographical recall. Autobiographical memories are complex and involve the recall of integrated and time locked multi-modal experiences as described by Damasio (1989). Some evidence of these close links between visual imagery and the formation of long term autobiographical memories comes from neuropsychological studies.

Ogden (1993) has described a number of higher visual deficits accompanied by severe retrograde autobiographical memory loss, following bilateral medial occipital infarcts in a patient M.H. This patient's visual deficits included visual object agnosia, prosopagnosia, and achromoatopsia, all deficits associated with bilateral lesions of the occipital cortex. It is postulated by Ogden that severe autobiographical amnesia was a consequence of the visual recognition and visual memory deficits. Similarly the encephalitis patient described by O'Connor et al (1992) suffered from visual agnosia, severe visuo-perceptual deficits and a severe retrograde autobiographical amnesia. They suggested that the loss of her past autobiographical memories may in part be explained by the concomitant visuospatial deficits which limited ability to generate and manipulate visual images.

Thus neuropsychological evidence may help to identify mechanisms by which visual imagery facilitates the retrieval of autobiographical memories. One possibility is that damage sustained to the medial temporal lobes results in very impoverished imagery formation and perhaps a loss of visual memory templates where the visual representation of complex objects and events are stored. In the case of M.H. (Ogden 1992), he is unable to recognise and visualise objects and scenes from long term memory. The drawings he performs and his verbal descriptions of objects are very impoverished and he also denies having dreams, suggesting a loss of ability to generate visual images. A second possibility may well be that the mechanism which brings stored visual representations of objects and events into conscious awareness may be impaired. In terms of the computational model of imagery and perception proposed by Kosslyn (1993) and Farah (1984), the problem may well be at the level at which the generated image is inspected. The visual buffer is the medium where visual images are constructed and maintained in an analogue form, which the subject can inspect and mentally transform.

In summary, it appears that visual imageability is a significant contributory factor in the retrieval of specific autobiographical memories. Auditory imagery also contributed to memory specificity. In contrast to visual imagery which has been extensively explored in recent years, auditory imagery has been largely neglected. It has been suggested that the phonological loop is involved in the temporary storage of auditory images but that there is less evidence for its involvement in evoking and experiencing images of this kind Baddeley & Logie (1992). Between-modality imaginal facilitation may be obtained under certain circumstances (Intones-Peterson 1980).

These circumstances occur when an object elicits an image in more than one modality. In a study described by Intones-Peterson (1980) when participants are asked to generate an auditory image of a commonly experienced event, they also generate a visual one. This is a pronounced effect as visual images in this experiment were generated to 95% of phrases. Sometimes the visual image preceded the auditory one as with "popcorn popping" the participants noted that they had to see the popcorn popping before they could hear it. The visual image before auditory image order was far more compelling than the reverse order. When given the task of generating visual images another group indicated that they also produced auditory images 53% of the time. Thus visual images and auditory images are clearly related with visual imagery having primacy over auditory imagery in the recollection of specific autobiographical events. It is also possible that such between-modality facilitation could occur for other sensory modalities also.

The limitations of this study are that cue words reflecting different imagery modalities (tactile, motor, olfactory, auditory) are not the same as physical representations. For example a cue word like lavender may not evoke the same memories of one's past as if participants are given the chance to actually smell such a cue. It may have been the case that participants relied on the visual images such cues evoked. A further experiment could use physical cues (pictures, sounds and olfactory stimuli) to examine the effect of such cues on the specificity of autobiographical memory.

The use of high and low imageable cues in this experiment and the previous experiment have successfully enabled us to manipulate the retrieval of autobiographical memories. The question arises however how closely this experimental manipulation analogises clinical findings. The following experiment examines the effect of a further manipulation of retrieval in autobiographical memory using high and low imageable cues and its implications for clinical findings.

Chapter 6

Imagery , Memory and Specificity of Future Events.

Experiment 3[1].

Both the previous experiments suggest that imageability is a factor which mediates specificity in autobiographical memory. Cues high in imageability appear to facilitate access to highly specific events compared to more abstract words, which result in the recall of more generic and summarised events. What is not clear from these results however is how they successfully map on to the variation in memory specificity observed in clinical conditions. It is possible, for example that there are many different mediators of non specificity and that the imageability of the cue word may be irrelevant for clinical cases. It would be of interest if one could demonstrate that the specific and general memories produced by manipulating imageability had additional effects which also modelled clinical findings.

The literature review in Chapter 3 showed that depressed and suicidal patients have difficulty in recollecting specific autobiographical events. They produce instead summarised or categoric memories reflecting repeated happenings (' shopping trips with my mum'). This deficit has implications for problem solving (Evans et al 1991) and it may prolong the course of the depressive episode (Brittlebank et al 1992). The present study focuses on a

---

[1] The experiment reported in this chapter is the third experiment in the following paper by Williams, J.M.G et al (1996)."The specificity of autobiographical memory and imageability of the future" Memory and Cognition, 24 (1) 116-125.

third clinical finding that overgeneral memory is associated with increased hopelessness for the future.

The prediction that non specificity in autobiographical memory may affect the way in which subjects imagine specific future events was investigated by Williams et al (1996: experiment 1). Suicidal patients and non depressed controls generated autobiographical events and possible future events in response to cue words. Correlational analysis of the relation between past and future specificity revealed that both overdose and control subjects showed significant associations between the specificity of memory and the specificity with which a future event could be generated. Since this data was correlational, the association between impairment in imaging specific past events and specific future events may have been due to other variables, for example depression or a general processing deficit due to the aftereffects of the overdose. However no relationship was found between depression and memory specificity in either the overdose or the control group, so depression is unlikely to have mediated the association between memory and future specificity found in both groups.

It also seemed unlikely that a general processing sluggishness due to the after effects of the overdose accounted for the results, as the correlation between specificity for the past and the future was also found in the control group where there were unlikely to be large individual differences in processing efficiency. Secondly there were no significant differences between groups on a verbal fluency task, which had been included to assess general cognitive processing. However the FAS may have been too easy a task to discriminate between the clinical and control groups used in this study. Thus an experiment was designed that could examine the experimental manipulation of recall specificity in a non clinical population. This study has a dual purpose; firstly to rule out alternative explanations for the clinical finding of a correlation between past and future memory specificity and secondly, to use imageability to manipulate retrieval and see how closely this experimental manipulation matched clinical results.

In summary, this experiment attempts to analogise the memory responses given by depressed and suicidal patients, by using high and low imageable cues to induce specific and generic modes of retrieval in a non clinical population. It is predicted that when subjects are induced to retrieve general memories similar to those produced by the clinical groups, they will then produce less specific images of the future.

Method

Design

The overall design employed was a 2 (group: specific induction, or high imageability cues and generic induction, or low imageability cues) x 3 (valence: positive, negative and neutral cues) factorial design. The first factor (group) was measured between subjects and the second (valence) was a within subject factor. All participants were randomly allocated to receive either specific or general induction in the 'training' phase by being exposed to either high or low imageable cue words. Subsequently all participants received the same cues in the test phase where the task was to imagine events in the future.

Subjects

Thirty four participants (29 females and 5 males) were recruited from the Undergraduate Subject Panel of the Department of Psychology, University of Wales Bangor. They were randomly allocated to two groups, specific and generic induction groups, N = 17 in each group. The mean age of both groups was 25.70 (S.D. 9.1) and 21.82 (S.D. = 5.2) for the Specific and Generic Induction groups respectively.

Materials

Eighteen cue words high in imageability were selected from Paivio's (1968) norms and matched for frequency with 18 cue words selected for their low imageability (Table 6.1). For the test phase, 18 cue words (6 positive, 6 negative, and 6 neutral) were used.

Table 6.1

High and Low Imageability Cue Words used in Induction Phase and Cue Words used in Test Phase

Induction Phase		
Specific (High Imageability)	General (Low Imageability)	Test Phase **Positive**
Butterfly	Thought	Laughing
Mountain	Greed	Friendly
Cloud	Moral	Proud
House	Attitude	Relaxed
Painting	Wisdom	Enthusiastic
Fire	Obedience	Helpful
		Negative
Grass	Explanation	Argument
Library	Boredom	Failure
Letter	Hearing	Nervous
Lake	Legislation	Blame
Factory	Mood	Lonely
Teacher	Permission	Embarrassed
		Neutral
Baby	Law	Shop
Nun	Effort	Advice
Poetry	Duty	Package
Robbery	Knowledge	Music
Sea	Upkeep	Conversation
Bouquet	Worth	Travelling

Procedure

Participants were run in groups of 8 and 9 and all testing took place in the same research room. Subjects were told that they would be participating in a short memory experiment and that they would be required to remember events from their past and imagine a situation in the future. All cues were presented using an overhead projector and simultaneously spoken aloud by the experimenter. Subjects were given 1 minute to complete their responses.

Specific Induction Procedure

Participants were instructed to produce real memories that occurred at a particular time and place in response to 18 cue words. The cue words were all highly imageable words. The following instructions were given:

> 'I will be showing you a number of cue words. For each one I want you to remember an event from your life which the word reminds you of. The events can have occurred at any time in your life and they may be trivial or important. You need only write down enough information to show that these instructions have been fulfilled. All responses will remain completely confidential and anonymous. It is however important to provide memories to all the cue words.
> For example if the cue word was 'choir'
> You might respond with,
> "attending a choir service last year which was filmed by the B.B.C.."
> or then again you might respond with,
> "attending choir services at school"

Generic Induction Procedure.

This condition employed cue words low in imageability. To minimise any potential confounds the instructions used were identical to those used in the above procedure with both a specific and general example of an event recalled. The following instructions were given;

> 'I will be showing you a number of cue words. For each one I want you to remember an event from your life which the word reminds you of. The events can have occurred at any time in your life and they may be trivial or important. You need only write down enough information to show that these instructions have been fulfilled. All responses will remain completely confidential and anonymous. It is however important to provide memories to all the cue words.
>
> For example if the cue word was " justice"
> you might respond with " remembering being told that a friend was banned from driving for 2 years"
> or then again you might respond with
> " following the Criminal Justice Bill debate in the papers and on television"

In both induction sessions the order of examples (specific and general) provided was counterbalanced to reduce experimenter bias. Once all subjects had completed the induction phase of the experiment, the test phase was begun.

Test Phase

Eighteen cue words were used in this phase (6 Positive, 6 Negative and 6 Neutral). Unlike the induction sessions these cue words were embedded within plausible sentences, (appendix C) The following instructions were given:

> " In this task there will be some sentences, and to each one, try and imagine some future event. It might be in the distant or near future and it may be an important or trivial event. You should write down the first thing that comes to mind in response to the sentences "

Subjects were not given examples of the type of image required as this might have interfered with the effects of the Induction phase.

Following the experiment, response protocols for both the memory and future phases were scored by the experimenter. An independent blind rater scored a random selection of responses from 10 subjects (180 responses in all). The results of a Pearson product correlation showed that the experimenter's rating was a reliable measure of specificity when compared with the independent ratings, ($r(180) = .82$, $p < .01$). Thus the experimenter's ratings were used in all analyses.

Results

Check on Success of Induction Procedures

The means and standard deviations of the number of specific memories and general memories produced following induction procedures are shown in Table 6.2. The number of specific memories provided by the specific induction (high-imageable cues) and generic induction (low imageable cues) was analysed using a one way ANOVA. There was a significant main effect of group ($F(1,32) = 57.65$, $MSe = 20.81$, $p < .001$). The high imageable condition produced more specific memories than the low imageable or generic group as predicted. Each subject's specificity score could vary between 0 and 54 (18 items, each with a maximum score of 3). The mean specificity score of the subjects in the specific induction (high imageable cues) group was 41.52 (SD = 3.98). The equivalent mean for the generic induction (low imageable cues) group was 29.64, (SD = 5.07). The experimental manipulation had succeeded in producing more specific memories following Specificity Induction and more generic memories following Generic Induction.

Table 6 2

Means and standard deviations for level of specificity of past events in response to cue words in Induction Phase.

Cue Type	Mean	S.D	Induction
Imageability (High)	41.52	3.98	Specific
Imageability (Low)	29.64	5.07	Generic

Note: Maximum Specificity Score = 54.

Effect of Specific and Generic processing on Future Images.

The mean scores for cue valences are shown in Table 6.3, and in Figure 6.1. Future event specificity following induction in the test phase is also shown in

Figure 6.1 A 2 (Group: Specific Induction, Generic Induction) X 3 (Cue Valence: Positive, Negative and Neutral) ANOVA was conducted. This revealed a significant main effect of Group ($F (1,32 = 31.41$, $MSe = 9.55$, $p <.001$). The specific induction procedure employing highly imageable cue words generated more specific images of the future than the generic induction group. There was also a significant effect of cue valence ($F (2,64) = 11.17$, $MSe = 2.37$, $p<.001$). Neutral cues produced more specific memories ($M = 14.64$, $SD = 2.15$) than positive cues ($M = 12.91$, $SD = 2.14$,) or negative cue valences ($M = 13.41$, $SD = 2.24$,) respectively. There was no significant interaction between group and cue valence ($F (2,64) = 0.81$, $MSe = 2.37$, $p>.05$).

Table 6.3

Means and standard deviations for specificity level of future events in response to positive, negative and neutral cues.

	Induction Type			
	Specific (High Imageability)		Generic (Low Imageability)	
Cue Type	M	S.D	M	S.D.
Positive	12.94	2.27	9.94	2.01
Negative	13.41	2.29	9.47	2.18
Neutral	14.64	2.31	11.29	1.99

Note: Maximum Specificity Score = 18

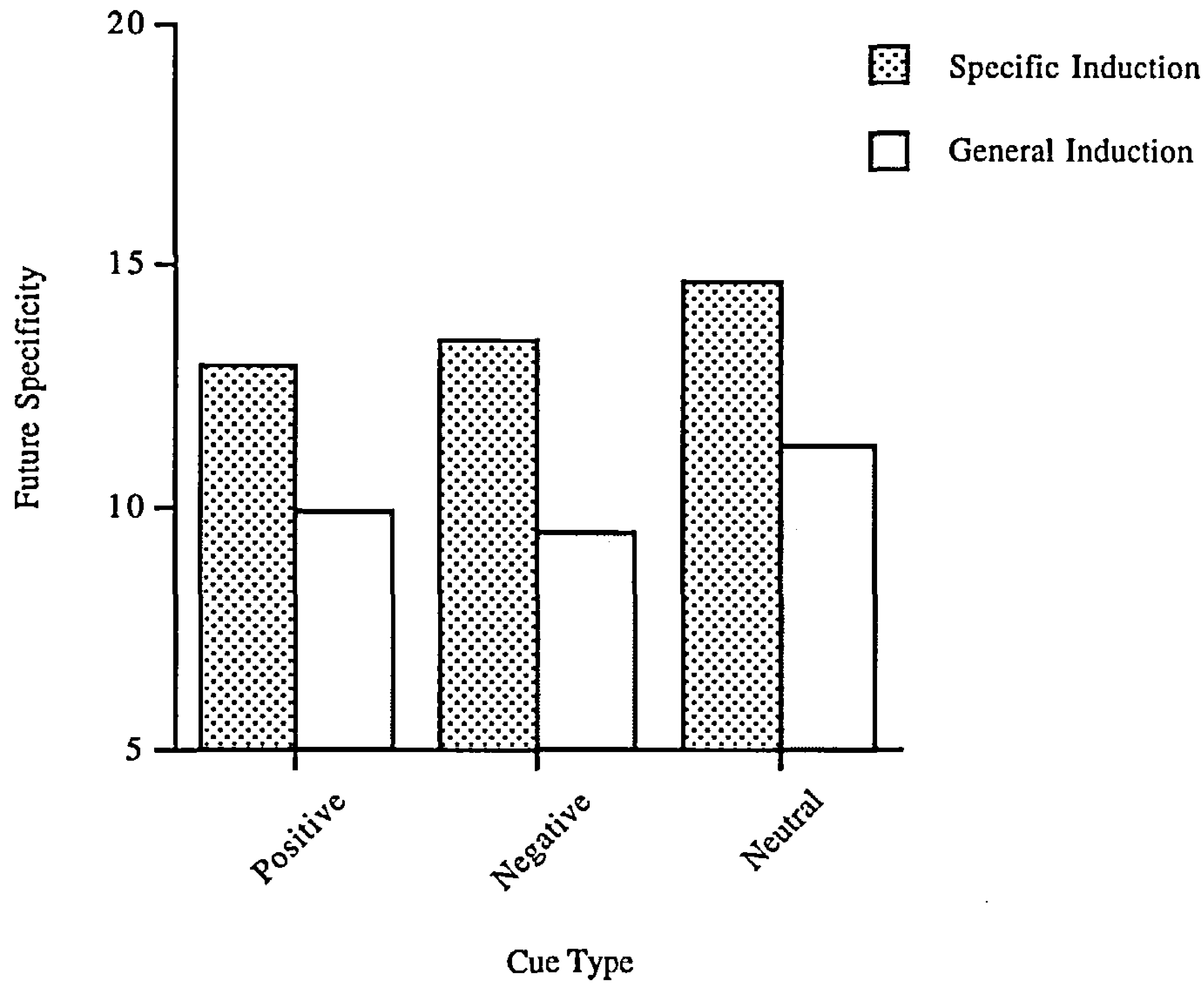

Figure 6.1 Future event specificity in the test phase following specific and general induction

Discussion

The aim of this experiment was to examine whether the specificity with which future events are imagined could be influenced by the specificity of retrieval of past events. Although the results of the previous two experiments had found that the imageability of cue words was a possible mediator of specificity, it remained unclear how closely this modelled clinical findings. If differences in memory specificity produced by subjects could have effects on their ability to generate specific images of the future, this would provide stronger evidence that the experimental manipulation of retrieval using high and low imageable cues was a possible analogue for the clinical findings.

Cue words differing in imageability were used in the induction phase and the method proved to be effective in inducing subjects to retrieve events from their past with greater or lesser degrees of specificity, as predicted from experiments 1 and 2. Subjects who had been induced to recall specific memories from their past using high imageable cues in the induction phase were more likely to generate more specific future event scenarios in the test phase. Similarly subjects who recalled more generic memories of past events when cued with low imageable cues, tended to imagine vague non specific images of the future.

As a major aim of this thesis is to examine the mechanisms that underlie the production of specific memories, the possibility of a link between specificity of retrieval of past events and the specificity of the future has important theoretical and practical implications. The present findings of a lack of specificity in the ability to imagine future events may explain in part the difficulties encountered by clinical groups in solving current life problems, the tendency to relapse and the large suicide risk they present.

The relationship between non specificity in autobiographical memory and hopelessness has also important clinical implications. Hopelessness about the future is a central element in suicidal behaviour. A number of studies have found that hopelessness mediates the relationship between depression and suicidal intent within suicidal populations (Salter & Platt 1990; Wetzel, Margulies, Davis & Karam 1980). Hopelessness has also been found to predict repetition of parasuicide 6 months later (Petrie, Chamberlain & Clarke 1988) and completed suicide up to 10 years later (Beck, Brown & Steer 1989; Fawcett et al 1990). Similarly the relationship between suicidal behaviour , life events and chronic difficulties has been established (Williams & Pollock 1993).

Does the way in which individuals retrieve events from autobiographical memory play a role in determining how they can imagine and predict future events?

This experiment suggests that the construction of specific models of the future depend upon accessing specific event representations from memory. Non specificity in terms of accessing this data base results in subjects being more dependent upon general or intermediate description for generating images of the future which permeates underlying hopelessness. A similar model might account for poor problem solving in depressed subjects. These findings also successfully model the results obtained with suicidal patients where the degree of difficulty in generating specific images of the future was found to be significantly correlated with the level of specificity in recalling autobiographical memories from the past (Williams et al 1996, experiment 1). The use of this experimental manipulation of retrieval style confirmed that while induction of specific or generic retrieval style might be implicit, it still influenced the specificity of future events. A link is therefore suggested between specificity of retrieval and specificity of imagining the future. Relating the results of this experiment to clinical findings suggests that the means by which cue imageability mediates the level of specificity in autobiographical memory may map closely onto the mechanisms that are disrupted in clinical groups.

The use of imagery to manipulate recognition memory has been used in a study by Dewhurst & Conway (1994). Recollective experience in recognition memory is enhanced when study items allow subjects to engage in imaginal coding, even when subjects attention is not explicitly directed towards the imaginal properties of the study items. Highly imageable words like pictures produce rich distinctive memory traces that are more likely to be recognised collectively than items that are low in imageability. The visual or imaginal code therefore appears to be a strong source of recollective experience and is thus a suitable variable to manipulate retrieval of autobiographical memories and also the ability to imagine future events.

Strategic retrieval of specific memories from autobiographical memory is enhanced by cue words high in visual imageability. While imageability is thus a potent variable, how the beneficial effects of this variable are implemented in autobiographical memory is uncertain. It is possible that the retrieval of specific autobiographical memories to low imageable cues is more effortful compared to cues high in imageability. Conway (1992) suggests that autobiographical memories are dynamically constructed on the basis of knowledge drawn from different memory structures. These structures include phenomenological structures, thematic structures and a configuration of a 'self' system which specifies goal structures, attitudes, and beliefs. A generative retrieval process mediates access to knowledge in such structures.

Low imageable cues are more effortful in terms of constructing a context which initiates a suitable theme to access specific event memories. In contrast the extra sensory perceptual information and context rich themes afforded by high imageable cues can efficiently access knowledge based structures. This alternative account of imagery effects is investigated in the following chapter through the use of a predicability measure proposed by Jones (1985,1988) and its effect on the retrieval power of the cues used in the autobiographical memory tasks.

Chapter 7

Images, Predicates and Retrieval Cues in Autobiographical Memory

Experiment 4

The results of the previous experiments suggest that imageability plays a significant role in the generation of specific autobiographical memories. High imageable cues act as efficient retrieval cues to mediate specificity while subjects tend to produce generic memories to low imageable cue words. It also appears that visual imagery is the imagery modality that contributes most significantly to this process. The application of this experimental manipulation in retrieval style has also successfully modelled clinical findings. Given that imageability of cues is such a powerful mediator, it is necessary to examine the processes underlying its effects.

This experiment extends the argument that retrieval of specific autobiographical memories and imagery are closely linked. Memories contain records of perceptual information, contextual detail, affective information and the different types of knowledge accessed during recollection is determined by processing initially undertaken at encoding. According to Johnson & Raye (1981) and Johnson, Foley, Suengas & Raye (1988) judgements about the source of memories are achieved through decisions on the basis of the evaluation of the phenomenal characteristics themselves. Subjects in reality monitoring tasks can determine whether a memory is internally or externally driven based on the phenomenal characteristics of that memory, which include perceptual and contextual and semantic detail. Memories of perceived events contain more sensory-perceptual and contextual detail than memories of imagined events. Furthermore Dewhurst & Conway (1994) suggest that encoding conditions that involve sensory-perceptual and semantic processing facilitates recognition memory. When sensory-perceptual knowledge and semantic details are activated during retrieval, the participant is consciously aware of past events. However when these details are not accessed and only linguistic aspects of the earlier event which are much less rich in sensory perceptual detail, the rememberer experiences only a vague feeling of familiarity about the event. Sensory perceptual knowledge and imagery effects are thus important determinants of retrieval in autobiographical memory.

Dual-coding theory (DCT; Paivio 1971, 1986, 1991) has successfully accounted for and predicted many memory effects in verbal learning paradigms in terms of the separate and joint contributions of non verbal and verbal representations and processes. A possible corollary of the DCT theory would be the formation of both a narrative form of memory and an imaginal form, which would mediate specificity in autobiographical memory. There has been much debate about the nature of imagery and whether it is best interpreted in terms of a propositional or a representational account (Pylyshyn 1987). This aspect of imagery is beyond the scope of this chapter and will not be further addressed. However Anderson & Bower (1973) suggested that the beneficial effects of imagery may result not directly from the experience of imagery per se but rather the efficiency with which the words to be remembered access a relatively abstract store of knowledge. This current chapter examines this theory to see if it helps explain how imagery mediates the retrieval of specific autobiographical memories.

A similar knowledge based account of imagery and its effects was expressed by Kieras (1978) who suggested that imagery effects were due to high imagery words being different from low imagery words on purely semantic attributes. Sentences consisting of words with superior values on these semantic attributes will be more easily learned. The semantic attributes are assumed to reflect differences in the semantic memory structures attached to the words. Concrete concepts would result in the formation of more propositions than abstract concepts. Adopting the spreading network activation model of Collins & Quillian (1978), the views proposed by Kieras (1978) and Anderson & Bower (1973) emphasise the relations or links between nodes in a network. This "semantic attributes" model or knowledge-based hypothesis of imagery effects was largely abandoned during the seventies due to repeated failures to specify a variable accounting for such effects.

Despite the neglect of knowledge-related accounts of imagery effects in verbal learning, Jones (1985, 1988) introduced a specific knowledge-based alternative to the notion of imageability. The variable which Jones argued possesses wide explanatory powers was termed 'predicability'. The predicability of a word is intended to be a measure of the ease with which a person can retrieve from memory different pieces of knowledge about whatever that word refers to. Jones (1985, 1988) demonstrated that there are significantly high correlations in assessments of the ease with which predicates of a word are summoned and of the ease with which images of a word can be formed.

Thus, contrary to the prediction of Kieras (1978) who argued that it was unlikely that a suitable variable reflecting knowledge-based interpretations of imagery effects was possible, a semantic alternative to imageability does exist. Jones (1985) also argues that both imagery and predication variables strongly influence the power of a retrieval cue, and argues that word predicability has greater explanatory powers. In general one cue or item can act as a successful retrieval cue for another if a link has been established to this other item's representation in memory. A critical type of link between these cue words is a knowledge based link, forged when the predicates that have been summoned activate other predicates or semantic attributes. The more likely that such predicates can be retrieved, the more likely that such links will be created. Thus highly predicable words should in general act as powerful retrieval cues, as has been observed in verbal learning experiments. This semantic alternative or knowledge based account of imageability effects can be related to the recall of specific autobiographical memories.

Baddeley (1993) suggests that autobiographical memory for specific incidents and semantic memory for personal facts represent different domains within the broad concept of a semantic/episodic system. Similarly Conway (1993) suggests that autobiographical memory is highly structured and that within this structure there is no specific knowledge easily identified as a memory. Rather there are constructions, compilations, or compositions of knowledge collectively viewed as 'memories'. Such conceptualizations are consistent with the idea that imageability may reflect the way in which such structures are registered in long term memory. The "generate, search and verify" model of memory retrieval Williams & Hollan (1981) accesses such knowledge structures in a recursive or cyclical fashion until the desired memory is recalled.

Thus a cue word high in predicability may mediate the retrieval of specific autobiographical memories, because it establishes more links between general events and event specific knowledge and in turn acts as a powerful index to increase the efficiency of the retrieval cycle. Cue words which are low in imageability and predicability however would require a far more effortful retrieval cycle in the search for a specific memory. Less semantic attributes are available, fewer links are established between concepts or life periods and a greater amount of memory search and information manipulation is necessary to construct a specific memory. Thus it may be the comparative lack of predicability of the abstract words used in the previous three experiments that result in the production of more general memories.

The purpose of the current experiment was to obtain predicability measures on cue words which have previously been used in autobiographical memory tasks, with a view to examining the predictive power of such a measure. Seventy two cue words in total were examined. These words are listed in Table 7.1. Of these words 36 (Group B) were taken from word norms used in a previous experiment with ratings for other perceptual modalities including high visual, auditory, motor, olfactory and tactile associated activity. The other Group A consisted of the cue words used in the first experiment. Both subjective and objective ratings of word predicability were obtained. The latter task required participants to generate and write down factual statements to the cue words as rapidly as possible, while subjective ratings involved subjects rating individual cue words as measure of predicability.

Table 7.1

Group A (Experiment 1)	Group B (Experiment 2)
Spinach	Moral
Photograph	Snore
Bouquet	Chlorine
Errand	Painting
Cradle	Football
Boredom	Worth
Obedience	Satin
Explanation	Laughter
Permission	Greed
Upkeep	Curry
Legislation	House
Hearing	Wool
Mood	Choir
Sea	Pump
Baby	Can opener
Teacher	Cry
Soul	Cheese
Knowledge	Wisdom
Situation	Axe
Factory	Butterfly
Grass	Spade
Letter	Thunder
Library	Coffee
Lake	Cloud
Duty	Hammer
Opportunity	Ice
Interest	Rose
Effort	Thought
Poetry	Sponge
Robbery	Smoke
Nun	Whistle
Law	Racquet
	Attitude
	Needle
	Fire
	Mountain

Method

Subjects

Twenty subjects rated the cue words used in experiment 2 (Group B). There were 7 males and 13 females with a mean age of 28.0 years. They were all psychology undergraduates and recruited from the student subject panel as part fulfilment of course credits. A further 20 subjects (11 males and 9 females) with a mean age of 33 years rated the words used in the first experiment (Group A).

Procedure.

Predicability Ratings (subjective)

Each subject rated a set of nouns shown in Table 7.1 The words were presented in randomised order and were arranged on successive pages of a booklet. The numerals 1 to 7 were printed with 1 and 7 representing lowest and highest ease of predication respectively. The first page of the booklet also contained the instructions. These were similar in form to those of Paivio et al (1968) and Jones (1985) and were as follows;

> "Words differ in the ease with which they can be described by simple factual statements. Some words can be put into statements quite quickly and easily while for others this can only be done with difficulty or not at all. The purpose of this experiment is to rate a list of 36 words as to the ease or difficulty with which they can be put into simple factual statements. As an example the word 'dog' would probably be judged as very easy to make simple factual statements

about because it can readily be put into statements. As a contrasting idea the word idea would probably be judged as very difficult to make simple factual statements about. Because words also differ in many other ways (such as how easy they are to mentally image or categorise) it is important that in making your ratings you attend only to the ease with which each word can be put into simple factual statements. Your ratings will be on a seven point scale where 1 is the low end and 7 is the high end. Make your rating by putting a circle around the number from 1 to 7 that best indicates how easy it is to put the word into simple factual statements. The words that are most difficult should be given a rating of 1 while words that are easiest to put into statements should be given a rating of 7. Words that are intermediate should of course be rated appropriately between the two extremes with a rating of 4 representing an average level of easiness. Feel free to use the entire range of ratings from 1 to 7".

2. Predicability Ratings (objective)

Having completed the first part of the experiment subjects were then requested to complete **objective** ratings on the same group of words. Predication Time was operationalized as the time taken (in seconds) to generate two statements for each word. The list of words used are shown in Table 7.1. The instructions used were as follows;

'Words differ in the ease with which they can be described by simple factual statements. Some words can be put into statements quite quickly and easily while for others this can only be done with difficulty or not at all. The purpose of this experiment is to rate a list of 36 words as to the ease or difficulty with which they can be put into simple factual statements. As an example the word 'dog' would probably be judged as very easy to make simple factual statements about because it can readily be put into statements.

For example 'A dog is a type of animal'

'A dog often lives in a kennel'

The factual statements must refer to the word concerned and not just contain it. What you have to do is attempt to generate as quickly as possible two factual statements of the above form for each word shown. In front of you is a pile of cards, each with a noun printed on it. When you are ready to begin the experiment, say 'NOW' and turn over the first card and try to generate the two sentences required. When you have written down the two sentences for a word tap the desk with your writing hand. Then when you are ready to repeat the procedure for the next word continue in this fashion until you have completed the list. The trials will be timed so try to carry out the task as quickly as possible yet ensuring that the sentences are as specified'.

The time taken by participants to generate the two factual statements was recorded from when participants indicated that they had saw the particular words and indicated by tapping that they had completed the two sentences. This procdedure was repeated for all words.

Results.

Both objective and subjective ratings of one group of cue words (Group B, Experiment 2) were analysed. Paivio imageability ratings were not available for this particular group of words, so visual imageability ratings from the word norms used in experiment 2 were used for all analyses These analyses are followed by a similar analysis of the cue words used in experiment 1 for which all Paivio imageability ratings were available.

The mean Predicability Rating and Predication Time for each word in Groups A and B are shown in Appendix B.

A correlation matrix (Table 7. 2) shows the significant correlations between all variables. A significant correlation was found between visual imageability Ratings of Group B words and Predicability Rating (r (36) = 0.84,$p < .001$). Mean Predication Time and Imageability Ratings showed a lower correlation of r (36) = -0.67,$p < .001$. Mean predicability ratings were correlated with objective mean predication time r (36) = -0.69, $p < .001$. (Correlation's for the last two measures are negative because a good predicational performance is reflected by a small Predication Time). Predicability Ratings were also compared with the Specificity memory score obtained for 36 words used in Experiment 2 showing a r (36) = 0.52, $p < .001$. A significant correlation was obtained for Predication time versus Mean Retrieval time for those words r (36) = 0.60,$p < .001$). Given the high correlation between predicability ratings and visual imageability (r = 0.84), there would appear be very little difference between both variables in terms of their association with specificity in autobiographical memory.

Table 7.2

Imageability, Predicability, Autobiographical memory measures of cue words in Experiment 2.

	P.Time	P.Rating	Visual I.	Specificity	M.R.T.
P.Time	1	-0.69	-0.67	-0.66	0.60
P.Rating		1	0.84	0.52	-.69
Visual I.			1	0.53	-.59
Specificity				1	-.67
MRT					1

P Time = Predication Time, P.Rating = Predicability Rating, Visual I. = Visual Imageability, Specificity = Memory Specificity, MRT = Retrieval Time.

All correlations are significant at p = < 0.001

Predicability ratings both objective and subjective were also analysed for the cue words used in experiment 1. Paivio's imageability ratings were available for these 32 cue words and these values were compared with the predicability rating results. The correlations between these measures are tabulated in Table 7.3.

Table 7.3.

Imageability, Predicability and Autobiographical Memory measures of cues used in Experiment 1

	P.Time	P.Rating	Paivio's I.	Specificity	M.R.T.
P.Time	1	-0.79	-0.74	-0.68	0.85
P.Rating		1	0.74	0.63	-0.74
Paivio's I.			1	0.45	-0.72
Specificity				1	-0.55
M.R.T.					1

P.Time = Predication Time, P.Rating = Predicability Rating, Paivios I. = Paivio's Imageability, Specificity = Memory Specificity, M.R.T = Retrieval Time.

All correlations significant $p < 0.001$.

All correlations were significant ($p < .001$). To further explore the independent contributions of imagery variables to specificity in autobiographical memory, a multiple regression analysis was computed where both measures of predicability were added to the regression model obtained in experiment 2. Table 7.4 shows the full correlation matrix for all the relevant variables entered in this model.

Table 7.4

Correlation Matrix Showing Relationships between all Variables

	Vis.	Aud.	Tac.	Mot.	Olf.	MRT	P.T	P.R.	Spec.
Vis.	1.00	-0.29	**0.52**	0.30	**0.54**	**-0.59**	**-0.67**	**0.84**	**0.53**
Aud.		1.00	-0.12	**0.59**	-0.36	-0.34	-0.00	0.02	0.23
Tac.			1.00	0.30	0.26	-0.22	**-0.48**	**0.64**	0.12
Mot.				1.00	-0.18	**-0.54**	**-0.34**	**0.47**	**0.49**
Olf.					1.00	-0.26	**-0.47**	**0.37**	0.24
Mrt.						1.00	**0.59**	**-0.69**	**-0.67**
P.Time.							1.00	**-0.69**	**-0.66**
P.Rating								1.00	**0.52**
Specificity									1

Note - Vis. = visual , Mot. = motor, Tac. = tactile, Olf. = olfactory, Aud. = auditory, Mrt = mean retrieval time, Spec. = specificity, P.Time = predication time, P.Rating = predicability rating significant correlations in bold (p < .001)

Multiple regression analyses were computed where both measures of predicability were added to the original regression equation obtained in experiment two which examined different imagery modalities. When all the variables were entered into a regression equation simultaneously, Predication Time was the only significant predictor of specificity in autobiographical memory (β = -0.58, p <.01). This predictor also accounted for 65% of the variance

The results of a stepwise multiple regression model where the variables were added separately are shown in Table 7.5. The model stopped at the third step after which none of the remaining variables were significant.

Table 7.5

Summary of Step wise regression analysis for variables predicting specificity in autobiographical memory (N = 36)

Variable	B	SEB	ß	R^2
Step 1				
P.Time	-0.29	0.05	-0.66	.43
Step 2				
P.Time	-0.24	0.05	-0.55	.51
Motor I.	1.12	0.47	0.31	
Step 3				
P.Time	-0.30	0.05	-0.69	.59
Motor I.	1.30	0.44	0.35	
Tactile I.	-0.89	0.37	-0.31	

R square for Step 1 = 43%; change in R square for step 2 = 8%. change in R square for step 3 = 8%.

The results of the step wise regression model suggest that when the predictor predication time is entered into the model at the first step, 43% of the variance in memory specificity is accounted for by this variable while both motor and tactile imageability each contribute a limited amount of variance to autobiographical memory specificity (8% in both cases). Given the high degree of multicollinearity between visual imageability, predicability rating and predication time, a further step wise regression model was computed where visual imageability was not included as a predictor variable and the results of this model showed that predication time still accounted for 33% of the variance in autobiographical memory specificity and motor and tactile imageability variances of 9% and 7% respectively.

Discussion.

Predicability was proposed by Jones (1985,1988) as a possible alternative knowledge based account of how the effects of imagery are mediated. Given that the retrieval power of cue words would be influenced by the variation in predicability, we were interested in obtaining predicability ratings for the cue words used in autobiographical memory tasks and comparing these measures with other measures of imageability. This study shows that both predicability ratings and the time taken to produce such predication statements correlated significantly with imageability ratings taken from Paivio's (1968) corpus of nouns for the cues used in Experiment 1 and also with visual imageability ratings for cues used in Experiment 2. These findings replicate those of Jones (1985, 1988). Similarly significant correlations were also found between predicability measures and memory specificity and the mean retrieval time taken to recall a specific memory.

Such a finding suggests that ease of predication is at least as good a predictor of specificity in autobiographical memory as imageability. When both measures of predication were included in a multiple regression analyses together with other measures of imageability including visual, tactile, motor and auditory and with memory specificity as the dependent variable; predication time emerged as the most significant predictor. The large measurement error and multicollinearity associated with this analyses which is not accounted for by a multiple regression equations suggests that these results should be interpreted with care and be regarded as essentially preliminary in the absence of a measurement model. These results raise the question however if both measures are equally good predictors of specificity in autobiographical memory given the high inter correlation between all three variables (predicability, predication time and imageability), then which one should be chosen as the most appropriate explanatory variable?

One line of argument would be that the high correlation between predicability and imageability indicates that they essentially reflect the same phenomena. That is subjects can produce predicates of words because they are easy to imagine and vice versa. For example, we can imagine a butterfly and our image may well be of a butterfly sitting on a rose bush or resting against the garden shed. To generate two factual statements derived from those images is not very effortful. Thus the time taken to generate predicates may reflect the times taken to generate those images that contain enough information from which the predicates can be derived. Thus the generation of specific autobiographical memories may involve both processes. Image generation activates semantic processing because imaging essentially entails accessing and searching knowledge structures in long term memory.

One possible advantage to predication however, is that it provides a direct behavioural measure of performance in the time taken to produce two factual statements or predicates. The effects of imagery can only be observed indirectly by manipulating the stimulus materials and task instructions and then noting the effect of these manipulations on task performance. However, although the measure of predication may be more direct, it relies on assessing how long a subject takes to write down the factual statements and thus is a relatively crude measure. Moreover, Richardson (1980) has argued that words with greater ease of predication can not only result in a range of verbal predicates, but can also produce spatial and visual predicates - that is they can readily produce visual images that are richly endowed with ancillary semantic information. Therefore according to Richardson (1980) imageability rather than predication persists as the more useful concept.

A study by Baddeley et al (1975a) explored the possibility that imageability effects may be mediated by the visuo-spatial sketch pad in working memory. If this were the case, then a concurrent visual spatial task such as pursuit tracking should reduce the advantage. Subjects were tested on noun-adjective pairs that were concrete (e.g. bullet-grey, strawberry-red) and on abstract pairs (e.g. justice -swift). Subjects learned and recalled such lists under control conditions and while performing a pursuit tracking task. Baddeley predicted a substantial advantage in favour of the imageable pairs and that if the visuo-spatial sketch pad was necessary for setting up the image, then tracking would severely disrupt this advantage.

The results of this study showed a massive advantage for the imageable pairs, a small but significant decrement resulting from tracking but no suggestion that tracking disrupted learning of the imageable pairs more than the abstract items. These results suggest that the imageability effect is not dependent upon setting up representations in the sketch pad system. The visuo spatial sketch pad it appears is responsible for setting up and manipulating images and for using imagery mnemonics in short term memory tasks but is not responsible for the imageability effects in long term memory. Baddeley (1986) suggests that these results are more consistent with an interpretation that suggests concrete and imageable items are easier to remember because they are represented more richly within the semantic system, a view consistent with that of Jones (1985,1988).

It is possible however that predicability and imagery effects are mediated not by their effects on the visual spatial system but because their ease of generation means that they take up less capacity in the central executive system of working memory. Strategic manipulation of such items (for example generating mnemonic strategies for encoding and retrieval, organisation and clustering items for recall) is less effortful with cues high in imageability and predicability. This subsequently allows more capacity for strategic processes to operate.

A similar suggestion emerged from the study of neuropsychological patients. Richardson (1979, 1984) has shown that better memory for concrete words is not present in adult patients who have suffered from closed head injury. In those earlier studies he interpreted this result to suggest that the patients have a particular difficulty in generating visual images. In a later study, Richardson & Barry (1985) replicated the pattern of data obtained for closed head injury patients but demonstrated that these same patients did show a concreteness effect when they were encouraged to use imagery. In other words, unlike normal subjects the patients with closed head injury did not spontaneously use imagery to remember the words but could do so when instructed. This reinforces the conclusion that the advantage for concrete words specifically relies on the effortlessness in generating images in response to those words, an issue which will be addressed in the following chapter 8.

More recent studies have suggested that the concreteness advantage for single words plays a less important role in memory for passages of text (Marschark & Cornoldi 1991; Marschark Warner, Thomson, & Huffman 1991). These authors have explored the utility of the dual coding model in cases where subjects are required to recall prose passages rather than word lists or verbal paired associates. Early studies of this topic suggested that prose passages that contain concrete referents are remembered more effectively than passages comprising primarily abstract material (Begg & Paivio 1969; Yuille & Paivio 1969). However it is clear that when the coherence and comprehensibility of the passages are controlled for then the concrete advantage is removed. Marschark et al have argued that the relational or distinctive elements in the material for recall may be more important than whether it is concrete or abstract. By 'distinctiveness' Marschark refers to the features of an item that make it readily discriminable from other items that are to be remembered. By relational he refers to the extent to which an item for recall can be organized and integrated in memory.

Marschark has also demonstrated that relational/distinctiveness information also appears to be more important than concreteness in free recall of paired associates (Marschark & Hunt 1989; Marschark & Surian 1989). It is possible that imagery may still play a role in enhancing the distinctiveness of verbal material but it is clear that imagery is not the only factor that can serve this function in accounting for the concreteness effect. The relational/distinctive aspect of imagery and recall has implications for the retrieval of autobiographical memories in that access to richer intermediate descriptions and specific memory traces may be mediated by such a process. Relational or distinctive aspects are very likely to affect the ease with which central executive resources engage strategies in organising, encoding and retrieval from memory.

It is likely that visuospatial working memory has an ambivalent relationship with the concreteness effect. In contrast to the effects of memory for prose it does appear that imageability is important in comprehension of prose. Eddy & Glass (1981) presented subjects with sentences for verification. Participants were required to read and verify sentences that were either concrete and highly imageable (e.g. The star of David had six points) or abstract (e.g. there are seven days in the week). Verification speed was slower for the concrete sentences. An earlier study (Glass Eddy & Schwanenflugel 1980) showed that reading verification was impaired when subjects had to retain a complex visual pattern. What is clear is whether the imagery effect observed is dependent on the nature of the task demands imposed on the participants.

Given the extremely high correlation between imagery ratings and both the objective and subjective ratings of predicability, it would appear difficult to separate these variables to assess their ability to influence specificity in autobiographical memory. The large measurement error is not taken into account in the multiple regression analyses and it is difficult to predict the relationship between all three variables (predicability, imageability and specificity in autobiographical memory). The issue remains unresolved, and reflects the problem of specifying an unambiguous criterion for imagery, (Paivio 1992). The effects of word predicability, ease of imagery formation and a relational /distinctive hypothesis may all contribute additive effects to enhanced recall and retrieval cue power. This may be achieved by releasing central executive resources which can then be used to generate more effective mnemonic strategies

The notion that cue words low in imageability and predicability are poor retrieval cues has been empirically demonstrated in the first three experiments. Furthermore Logie (1995) suggests that the central executive component of working memory is responsible for image generation and manipulation and Kosslyn (1994) proposed that working memory is involved in transferring to and from long term memory to the visual buffer described in his (1980) model of imagery. If it is the case that greater effort is required to generate specific memories to such degraded low imageable cues and that less effort is needed when high imageable cues are used to cue autobiographical memory, it should be possible to assess this directly. Such a hypothesis is consistent with studies from neuropsychological and clinically depressed patients. However an index of effort is needed to fully explore this hypothesis. The following chapter discusses the role of the central executive and retrieval from autobiographical memory

Chapter 8

Working Memory and Autobiographical Memory

Cues low in imageability and predicability are poor retrieval cues in autobiographical memory as the four previous experiments have demonstrated. This raises the question of the amount of effort required to construct an autobiographical memory. High imageable cues appear to mediate speedy access to specific event memories while more general event memories are retrieved to low imageable cues with prolonged retrieval times. If it is the case that greater effort is required to generate specific memories to degraded low imageable cues, then it should be possible to assess this directly, using a measure of central executive capacity as an index of this effort.

Working memory and autobiographical memory are closely linked, via the control functions of the central executive component of working memory. Attempts by Baddeley (1996) to specify in more detail the functional aspects of the central executive have identified two critical aspects; firstly the ability to switch retrieval strategies and secondly the capacity to hold and manipulate information in long term memory. Both functions have clear implications for the retrieval of autobiographical memories. This chapter reviews the central executive component of working memory and its role in the retrieval of autobiographical memories.

Depressed and suicidal patients have difficulty in recollecting specific autobiographical events. Strategic retrieval of events from autobiographical memory is a staged process involving intermediate descriptions and Williams (1996) has proposed that under some circumstances retrieval from autobiographical memory may be truncated due to capacity limitations in working memory. Such truncated searches result in the retrieval of general memories and it is suggested that the retrieval process is aborted because the search for specific memories is too effortful. Research to date has been limited because of the difficulty in finding an index of cognitive effort devoted to a particular task.

What evidence is there to support the suggestion that central executive resources are involved both in the storage and retrieval of autobiographical memories? The retrieval of such memories is a dynamic interactive process and Shallice (1986), Della Salla (1993), Conway (1993), Baddeley (1993), and Williams (1993, 1994, 1996) suggest that the quality of recollected memories depends upon adequate attentional resources. Detailed accounts of autobiographical retrieval described by Williams (1978), Williams & Hollan (1981) and Conway (1993) are consistent with the notion proposed by Hasher & Zachs (1988) that retrieval of autobiographical traces is an elaborate and particularly demanding process. Conway & Engle (1993) provide empirical evidence for the role of working memory in the retrieval of information from long term memory and suggest that retrieval involving active search processes depend upon limited working memory capacity.

The retrieval of autobiographical memories is typical of such active search processes. During the first step of recollection, a retrieval plan is initiated to answer a specific autobiographical question (for example to retrieve a specific autobiographical memory in response to a cue word). This question sets a conceptually flexible search strategy in motion by means of a limited number of preliminary generated contexts or event structures. This goal directed generation can be equated with similar strategies employed in problem solving tasks and often takes the form of a trial and error approach reminiscent of the recursive searching strategy postulated by Williams & Hollan (1981) and Williams (1989, 1994).

Once an appropriate set of event structures have been generated in response to a cue word, the next step of recollection is to verify the remote memory trace that has been generated. This verification step also involves checking that the memory satisfies the experimental constraints and is a specific memory of a personal event. The veracity of the retrieved memory trace is achieved by cross checking it with other general event structures and general event knowledge. These features according to Della Salla (1992) make autobiographical accounts particularly susceptible to confabulation.

A third step in autobiographical recollection involves the verbal output of this memory trace. Thus "autobiographical recollection is viewed as a novel and multi-componential sequence of steps and one of the functions of the attentional system is to deal with the planning and checking components of all new tasks" (Della Salla 1992, pg. 138). A prediction from such a generative retrieval process is that the construction of an autobiographical memory is an inherently effortful process, which is dependent upon adequate central executive resources. Consider the retrieval cycle that would be initiated in response to a cue such as 'mountain'. Elaboration of this cue into contexts such as "trips up mountains during the summer" or " that first skiing holiday with the family" are used to search memory. Having accessed a suitable general event such as the latter, a more refined search of this time period results in the construction of a particular specific memory "my first skiing lesson". Conway (1992) suggests that the Supervisory Attentional System modulates the construction of such contexts which are used to search memory, and that general events provide the necessary indices to access specific events.

Neurological studies of impaired memory also support the role of central executive controlling retrieval processes in autobiographical memory. Impairments presented by frontal lobe amnesics such as clouding of memory and confabulations suggest that frontal lobe injury prevents access to long term memory (Stuss & Benson 1984). Furthermore Wilson & Baddeley (1988) conceptualise frontal lobe memory impairments in terms of a disruption of a central processing mechanism and in particular as being a disruption of the SAS (Shallice 1988). They also characterise frontal lobe impairments as a *dysexecutive syndrome.* In terms of a structural model of autobiographical memory such impairments are strongly indicative of a malfunctional generative cycle, most likely occurring at the evaluation stage of retrieval. Thus the study of frontal lobe amnesics provides some support for a centrally mediated autobiographical memory retrieval.

Work by Greene, Hodges, & Baddeley (1995) provides further evidence for the role of the central executive in the retrieval of autobiographical memories. They studied central executive function and autobiographical memory in a group of patients with early dementia of the Alzheimer type. Executive function was assessed by a letter fluency task and two dual performance tasks (a test of everyday attention and a modified version of Baddeley's visual tracking task). All three tasks correlated with some components of autobiographical memory suggesting that the central executive monitors and modulates such retrieval.

In accounting for the overgeneral memory recall of depressed and parasuicidal groups Williams (1996) has suggested that an increase in intermediate categoric descriptions may block the retrieval of specific episodes. In response to a cue word, a number of possible event structures or descriptors are usually generated, which in turn index other possible memories and ultimately result in the retrieval of a specific episode. At some point in the retrieval process, the production of such intermediate descriptors must be inhibited. This process requires central executive or SAS involvement, such that where central executive capacity is reduced, the resulting reduction in inhibition leads to impoverished retrieval and the production of overgeneral memories.

Williams (1996) reviews evidence from studies of young children, and of elderly and brain damaged groups to show how the ability to inhibit these relatively automatic categoric description processes develop during the third and fourth years of life, and how this ability is affected by reduced working memory capacity in ageing and in brain damage. In each of these groups, generic autobiographical memory is the result. For example, Winthorpe & Rabbitt (1988) found that elderly participants who had reduced working memory capacity (assessed using a sentence span task) were more likely to be generic in their recall of events from their lives.

In emotionally disturbed groups, it is possible that mnemonic interlock (increased production of intermediate categoric descriptors) is due to the same truncated search. This is consistent with the suggestion of Ellis and Ashbrook (1988) and Hertel and Hardin (1990) that depressed subjects show poor memory partly because of limited resources. However, these 'cognitive effort' or 'resource allocation' models of memory deficits in depression, despite their intuitive appeal, have not attempted to measure such deployment of resources independently. If future research is to examine directly the hypothesis that memory search is aborted because subjects find it too effortful relative to their working memory capacity (Williams & Dritschel, 1992; Williams, 1996) it will need to assess such capacity directly. The role of working memory particularly its central executive component is important for understanding the retrieval of specific autobiographical memories. The next section reviews the working memory model as a background for focusing on the measurement of central executive capacity.

Working Memory and Central Executive Resources.

Working memory is necessary for any task that involves temporary storage of information and has been implicated in such ecologically important tasks as reading, problem solving, reasoning, and understanding spatial relations (Baddeley 1986, Daneman & Carpenter 1980, Kyllonen & Christal 1990, Shute 1991). General capacity models of working memory define working memory as information in long term memory that has been activated above some resting state to a level that makes it available to cognitive processes. Essentially working memory provides a window that contains information that is to be attended to or operated on and thus it monitors output or autobiographical memories that have been activated within long term memory.

Baddeley and Hitch (1974) identified three components of working memory; the central executive, phonological loop and the visuo-spatial sketch pad. The most extensively explored sub component is the phonological loop (see Gathercole and Baddeley 1994 for a review). Much work has also addressed the functional aspects of the visuo-spatial sketch pad in terms of visual and spatial processing (Logie 1995). The central executive component has proved to be less tractable to empirical research and early accounts of this component were largely descriptive and vague. It fulfils many different functions primarily regulatory in nature. The central executive co-ordinates activity within working memory and controls the transmission of information between other parts of the cognitive system. In addition it allocates information to the phonological loop and visuo-spatial sketch pad and also retrieves information from long term memory. These activities are fuelled by processing resources within the central executive which have limited capacity.

The efficiency with which particular functions are fulfilled depends largely on whether other demands are simultaneously placed on it. The greater the competition for the limited resources of the executive the less efficient it will be at fulfilling particular functions. Cognitive tasks that are assumed to involve the central executive include mental arithmetic (Hitch 1980), recall of lengthy lists of digits (Baddeley and Hitch 1974), reasoning (Baddeley and Hitch 1974, Oaksford et al 1996), semantic verification (Baddeley, Lewis, Eldridge, & Thomson 1984a) and the recollection of events from long term memory (Hitch 1980).

Baddeley (1986) attempted to specify the central executive in more detail and much of this work on the regulatory functions of the central executive were guided by a model of the attentional control of action developed by Norman & Shallice (1980), and Shallice (1982,1988). According to this model action is controlled in two ways; firstly well learned or automatic activities are guided by schemas that are triggered by environmental cues such as driving, word processing etc. which are also regulated by contention scheduling systems. When novel activities are involved or when routine habitual schemas are interrupted by other threatening environmental stimuli, a higher level Supervisory Attentional System (SAS) intervenes to control action. This SAS inhibits and activates schemas directly and thus can override the routine process of contention scheduling. Baddeley (1986) suggested that the central executive is analogous to the SAS, and this model has the advantage of linking working memory to neuropsychological studies of frontal lobe patients.

Baddeley (1996) identifies two dominant approaches to attempting to understand the mechanisms underlying executive control, one stemming from neuropsychology and the other from psychometric tradition. Useful insight into the nature of the SAS is provided by neuropsychological patients with frontal lobe damage, and there is abundant evidence that disorders of executive control are associated with frontal lobe damage (Shallice 1982, 1988). Frontal patients typically show a paradoxical combination of behavioural perseveration when they repeatedly perform the same action or say the same phrase or word, and increased distractibility. Shallice (1988) explains both types of behavioural disturbance as manifestations of SAS impairment resulting from frontal lobe damage. The SAS is unable to intervene and inhibit the activity of schemas while selectively activating the activity of a more appropriate schema. Thus one approach to understanding executive processes is to study such patients with frontal lobe dysfunction (Duncan 1986, Duncan, Johnson, Swales and Freer in prep, Shallice and Burgess 1991,1993).

Psychometric approaches to the central executive and the study of individual differences represents a second and related approach to the analysis of the central executive. The more traditional of these approaches has been based on the assumption that intelligence measures reflect the operation of a central cognitive processor which could potentially be identified with the central executive of working memory. This raises the question of whether intelligence is better considered as reflecting a single general factor, or capacity for example Spearman's 'g' or whether intelligence is best regarded as constituting a number of sub processes. This question is pursued using populations of normal subjects (Kyllonen and Christal 1990), of neuropsychological patients (Burgess and Shallice in press; Della Salla, Gray, Spinnler & Trivelli in prep and Duncan 1986) and of normal elderly subjects (Rabbitt 1983; Salthouse 1991). The results of such studies are clearly relevant to the concept of working memory but are also critically dependent on the nature of the tasks used and the subject groups tested. Lehto (1996) finds correlations between some aspects of frontal tasks and some working memory tasks while Waters and Caplan (1996) obtains patterns of correlations that are largely specific to type of material and method of processing.

The classical psychometric and traditional neuropsychological approaches to identifying central executive activity are thus both problematic. Specifying the neuroanatomical substrate of executive control in the frontal lobe leaves the functional aspects still rather vague. Adopting the psychometric paradigm does not answer whether executive control or intelligence reflects the operation of a single unitary controller or a number of interacting but independent sub processes. Recent research has attempted to fractionate central executive function in an attempt to address these issues. The first attempt to devise a measure of executive function stemmed from work on the memory deficit accompanying Alzheimer's disease. Results were consistent with the hypothesis that the capacity to combine performance on two tasks (for example concurrent visual tracking and digit span) a capacity regarded as a necessary function of the central executive, is particularly impaired in AD patients. Evidence of a strong association between poor dual task performance and behavioural problems commonly seen in frontal lobe patients demonstrated that for patients with such behavioural disorder, there was a clear decrement in dual task performance when the box crossing and digit span tasks were combined (88% to 65%) whereas the behaviourally undisturbed group showed no significant decrement (88% to 84%). Both groups did not differ significantly either on verbal fluency or the Wisconsin Card Sorting Test.

These findings are consistent with the view that the central executive involves a number of sub components, possibly associated with the functioning of different aspects of the frontal lobes. More specifically it implies that the disinhibited and disordered behaviour that is sometimes found in frontal lobe patients is associated with difficulty in distributing attention. The question arises whether dual task performance is a better measure of executive function than the more established tests such as verbal fluency. The latter test is however a good measure of some aspects of central executive and is particularly sensitive to the effects of a concurrent digit load (Baddeley et al 1984). Recent work by Engle (in press) finds that verbal fluency relates closely to working span measures of the type devised by Daneman and Carpenter (1980).

A much more plausible interpretation may be that the two tests simply measure different executive processes, with the two processes being differentially associated with the behavioural problems seen in dysexecutive patients. For example impaired verbal fluency may be associated with retrieval problems, resulting in disruption in autobiographical memory either associated with extreme poverty in recollection or in so called dynamic aphasics, patients who have great difficulty in initiating retrieval, or in the apparently opposite pattern also found in dysexecutive cases where recollection is fluent but inaccurate resulting in confabulation (Baddeley & Wilson 1986).

Attempts to specify the functional role of the central executive component of working memory have concentrated on three predominant areas, namely that of random generation, selective attention and the temporary activation of long term memory. The next section reviews these aspects.

Activation of long term memory.

Central executive capacity is responsible for the temporary activation of long term memory. The idea that working memory might represent the selective activation of representations in long term memory is not a new one and could possibly be regarded as the modal view (Crowder 1993; Roediger 1993). The phonological loop itself depends upon activation of information in long term memory. Working memory may be conceptualised as a general retrieval system monitored by the central executive, which can encode and retrieve information both from the two slave systems and form temporarily activated information from long term memory.

Despite theoretical assumptions that working memory and central executive processes are involved in the retrieval of information from long term memory there have been few empirical studies to investigate this. There is considerable evidence that working memory plays an important role in a wide variety of tasks from learning, reasoning, reading, comprehension and problem solving. Less evidence has been provided for the role of working memory and retrieval. However this aspect of working memory has been investigated by Turner & Engle (1989), Conway & Engle (1993) and Engle (in press).

Conway & Engle (1993) examined individual differences in working memory capacity and how those differences affect performance on fact retrieval tasks. They also attempted to delineate the effects of limitations in working memory capacity on retrieval from both primary and secondary memory. Most experiments designed to study retrieval from memory have used tasks aimed at tapping retrieval from either primary or secondary memory but not both. Working memory may reflect the temporary activation of representations of long term memory (Cantor & Engle 1994) where high span subjects as measured by Daneman & Carpenter's (1980) sentence span task are able to activate more extensive regions of long term memory. Given the parallels between retrieval of information from long term memory and the retrieval of autobiographical memories combined with our hypothesis that the retrieval of specific autobiographical memories is an effortful process, this paper is of considerable interest and will be reviewed in detail.

The concept of memory activation adopted by Cantor & Engle (1993) is taken from Anderson's ACT* model (Anderson 1988). This model assumes that primary memory consists of information in secondary memory that has been activated or stimulated above some critical threshold. (Primary memory has been equated with the current contents of consciousness and deals mainly with perceptual processes; this system is distinguished from secondary consciousness or memory proper which consists of memories of the distant past (James 1890)). Activation is considered to be a limited resource that spreads automatically among related concepts. As activation levels of a concept rises, so does its accessibility.

Anderson (1976) designed the fact retrieval paradigm in an attempt to measure the amount of activation available to long term memory. In this task subjects memorise a number of sentences that consist of a subject and a predicate (e.g. the baker is in the kitchen). The number of predicates varies with each subject. After the learning phase, there is a verification test in which the subjects must distinguish between the studied sentence and the foil sentences. Reaction time and error rates are found to be consistently higher with those sentences with a larger fan size (greater number of predicates and thus increased aactivation) and it is this phenomenon that is termed the fan effect.

Following these assumptions and techniques, Cantor and Engle (1993) propose that high working memory span subjects have more activation available and in accordance with this view they demonstrate that the slope relating set size to verification is steeper for subjects with a low working memory span. A later study by Rosen & Engle (cited by Engle in press) studied the capacity to generate items from a semantic category such as animal names, demonstrating that performance is significantly higher in high working memory span subjects. To further explore the link between Anderson's fan effect and the closely related demonstration by Sternberg (1966) of a linear relationship between the time it takes to decide whether a probe item comes from a set that has just been presented and set size, Conway and Engle (1994) designed a further set of experiments.

Firstly subjects are taught groups of two, four, six and eight letters to a point at which when asked for that group, they can provide the constituent letters perfectly. When given a group and a particular letter they can indicate whether that letter belongs to that group. As predicted, reaction time increases linearly with the number of items within the probed group, with the slope being steeper for subjects with low working memory span. By specifying the set first (e.g. the four letter set), but delaying the presentation of the probed letter, Conway & Engle (1994) were able to distinguish and separate out the time taken to access a given set from the time taken to check it for the presence of the probe letter.

Results showed that working memory span does not influence the time taken to access the set, only the time taken to verify the presence of the probe. They thus concluded that the former retrieval process (time taken to access the set) is relatively automatic and does not depend upon limited working memory capacity, whereas the latter involves an active search process that is capacity dependent. This offers a possible model for the retrieval of specific autobiographical memories, which is a dynamic interactive process requiring attentional resources and depends upon the same limited capacity system. The model of working memory proposed by Conway & Engle (1994) is also entirely consistent with the idea of a central executive as being a general attentional system. However they view this executive as being limited principally in its capacity to inhibit irrelevant information and it is this aspect of central executive function that is now reviewed.

Central Executive Function and Selective Attention.

Central executive processing is primarily concerned with the attentional demands imposed by a wide range of tasks. The capacities likely to be required by a general central executive system include the ability to time share and switch retrieval plans. An additional capacity would be the ability to attend selectively to one stream of information while discarding others - selective attention. Hasher & Zachs (1988) argue that when working memory as well as selective attention are functioning normally, inhibitory mechanisms "serve to limit entrance into working memory, information that is along the goal path of comprehension" (p.122). Hasher & Zachs provide considerable empirical evidence that working memory deficits in ageing individuals result from reduced ability to inhibit irrelevant information. It is possible that the reduced ability to inhibit as we get older is a result of reduced attentional resources and Baddeley (1996) suggests that the principal implication of such findings is the support they lend to the view that the capacity for focused selective attention provides a promising further component of any complete specification of the central executive.

While work on the central executive and the retrieval of information from long term memory and its role in selective attention have been relatively recent developments, the role of the central executive and random number generation represents early attempts to specify in detail the functional role of the executive. Random number generation and more recent theoretical developments of this task in relation to central executive function are next discussed.

Random Generation as an index of central executive capacity.

Early investigations into the central executive were prompted by the problem of explaining a set of results published in 1966 by Baddeley et al. Participants were required to generate random sequences of letters. This task was then combined with a card sorting task and the speed of generation varied from one second to 4 seconds. The randomness of the sequences decreased with speed of generation and the greater number of response alternatives in the card sorting task. These results were consistent with the notion that random generation depends upon a system of limited informational capacity - hence the more rapid the rate, the less random the output.

Despite its lawfulness this pattern of results remained difficult to explain until the arrival of the Norman and Shallice model (1980). It was proposed by Baddeley (1986) that the requirement to make sequences random depended upon the constant intervention of the Supervisory Attentional System (SAS) to override habitual responses and stereotyped responses like digrams or acronyms. As the SAS was presumably also required for the decision process in sorting the cards into different categories, card sorting also interfered with the randomness of the letter sequence generated.

This initial suggestion has led to the adoption of random generation as a secondary task that might be assumed to disrupt the operation of the central executive and hence be used as an index of central executive capacity. Previous studies have used random generation as a secondary task in a wide range of tasks ranging from learning an artificial grammar (Dienes, Broadbent and Berry 1991, Green and Schanks 1993) to playing chess (Baddeley 1992) to stimulus independent thought (Teasdale et al 1995), and reasoning (Oaksford, Morris & Williams 1996).

The vast majority of studies of random generation have used verbal output typically involving letters and or numbers. Such tasks are however logistically cumbersome and limit the use of random generation as a secondary task. Random key pressing as an alternative generation procedure was explored as a possibility by Baddeley (1996). Participants were required to generate 100 random key presses using a specially constructed keyboard at each of three rates, 0.5, 1, and 2 seconds per response. Results indicated that the degree of randomness was somewhat less for key pressing than for digits but showed an equivalent decline when generation speed increased.

A second study explored the assumption that random generation reflects the limited capacity of a general purpose executive system. Random key pressing was combined with a memory span task in which subjects were required to recall sequences ranging in length from two to eight digits. If performance depends upon a general memory system there should be interference between the verbal memory task and the visuo-spatial generation task. Furthermore if the system reflects a limited capacity working memory system then the degree of disruption of random generation should increase with concurrent memory load. Both these predictions were supported in this experiment.

The influence of the random key pressing task was then investigated on a range of further tasks. Articulatory suppression had no effect on random generation which was however substantially disrupted by a category generation task in which subjects had to produce as many items as possible from a specified semantic category such as animals or fruit. Such verbal fluency tasks do seem to depend relatively heavily on executive resources as evidenced by their susceptibility to interference by concurrent digit span (Baddeley et al 1984) and to impairment in dysexecutive patients (Baddeley and Wilson 1988). A greater degree of impairment was produced by a concurrent requirement to perform the AH3, a demanding test of fluid intelligence (Heim 1975). Duncan (1993) has argued that performance on such tests of intelligence is an index of executive function.

The overall pattern of results therefore has been broadly consistent with the assumption that random generation competes for the same limited capacity as do a range of tasks that depend to a greater or lesser extent on central executive functioning. A further finding in this series of experiments has been the demonstration that when random generation by key pressing was combined with spoken random number generation, concurrent digit generation reduced the randomness of key pressing by about the same amount as concurrent category generation. The reciprocal effect of random generation on digit generation was rather less (Baddeley 1996).

In order to explain these results and describe the processes underlying random number generation, Baddeley (1996) appealed to the Search Associative model (SAM) originally described by Raaiijmakers and Shiffrin (1981). This involves setting up a retrieval plan, running it and checking that the output which is judged to be suitably random is emitted at the appropriate time. It is assumed that the decrement in randomness seen at higher speeds occurs principally because of the time taken to shift from one retrieval plan to another. If this were not time limited then the subject could presumably switch every time and not bother to check the randomness of output. If however the same retrieval plan is used repeatedly then the stream of responses is likely to be stereotyped and non random. Anything that tends to interfere with the capacity to switch retrieval plans will tend to increase the redundancy of output. This model of random generation is depicted in Figure 8.1.

MISSING PAGE REMOVED ON INSTRUCTION FROM THE UNIVERSITY

Two experiments were designed by Baddeley et al (1996) to test the switching hypothesis directly. If the need to switch retrieval plans is the source of disruption in performance then it should be possible to devise a plan that places minimal load on memory and other executive processes but has heavy switching demands. A verbal equivalent of a trails task thought to be particularly sensitive to frontal lobe damage was used. This task involved counting and reciting alternate letters and numbers of the alphabet (A-1, B-2, C-3, etc.). Whereas neither counting nor reciting the alphabet affected the randomness of key pressing, the concurrent alternation task markedly reduced randomness. This was replicated starting subjects on each trial with a different initial number letter pair (F-9, 10-G etc.). Despite the minimal memory load and the predictable nature of the sequence, a substantial reduction in randomness resulted. Thus Baddeley (1996) concludes that random generation disrupts the operation of the central executive by its demand for the constant switching of retrieval plans.

The process of generating a random sequence of numbers and the retrieval of autobiographical memories share common features in terms of setting up retrieval plans and monitoring output. Both processes can be regarded as central executive functions competing for similar resources. The recall of specific autobiographical memories also involves the setting up of a retrieval plan. For example when a participant is given a cue word 'restaurant' a retrieval plan is initiated where the description acts as an index for memories of previous visits to restaurants. This plan or cycle is then searched or run and a candidate episode which fits the description (e.g. a visit to a Chinese restaurant to celebrate my birthday) is retrieved.

The specificity of output can vary and the individual has some strategic control over how much of the memory hierarchy has to searched in order to meet the requirements of the task. The output is then checked for specificity or verified and if judged suitable is subsequently emitted as a memory response. If working memory capacity is reduced this search process is truncated and a general memory such as 'eating meals in restaurant on holidays' is retrieved. As in random number or keypressing generation reduced capacity to switch retrieval plans or complete a search cycle in the case of autobiographical memory reduces the specificity of the output. This functional model of retrieval in autobiographical memory is depicted in Figure 8.2

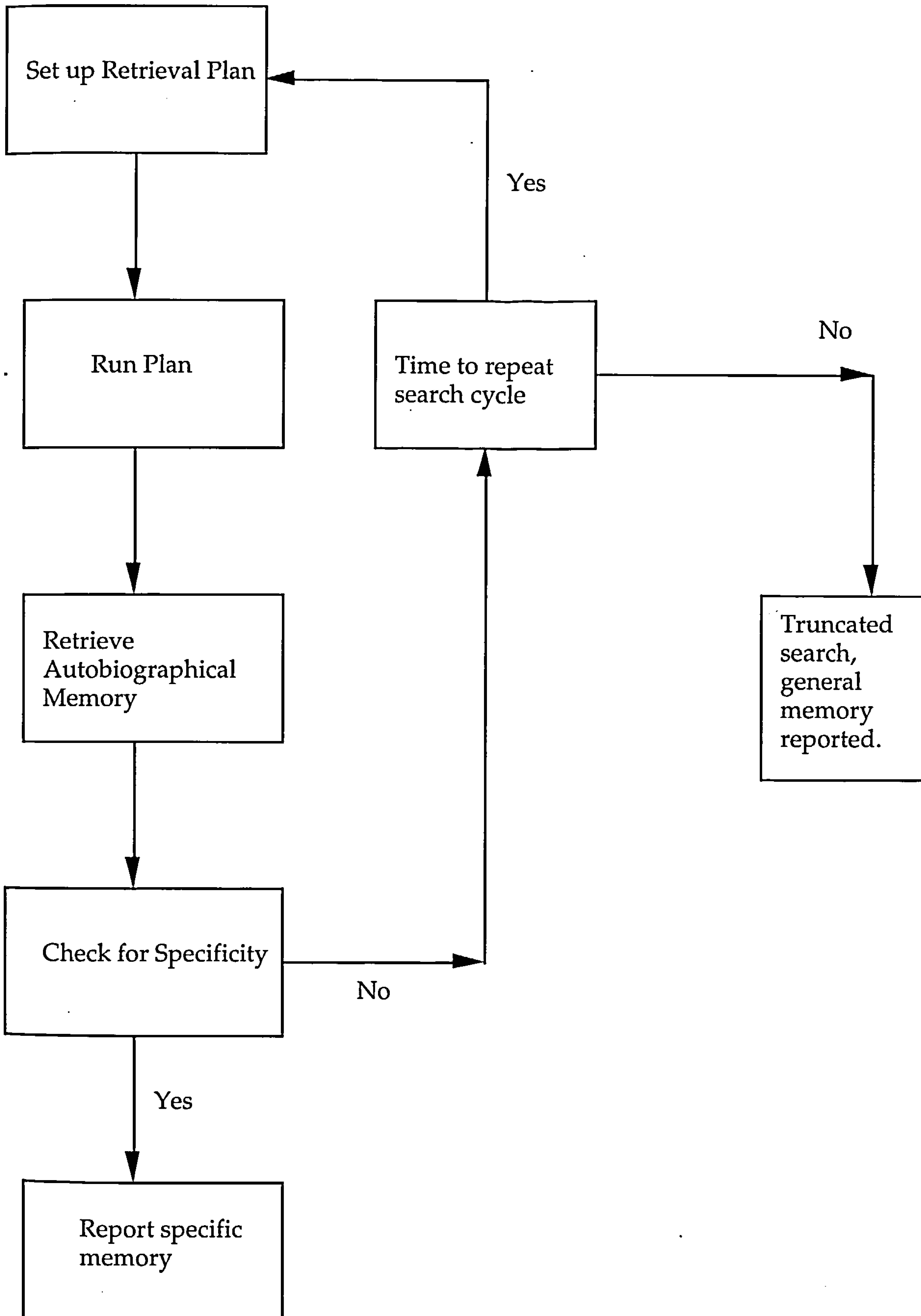

Figure 8.2. Model of Retrieval in Autobiographical Memory

According to Ellis & Ashbrook's (1987) resource allocation model of depression, depressed groups have reduced cognitive capacity. It seems reasonable to suggest that emotionally disturbed groups have a predominantly generic autobiographical memory because the retrieval of specific memories is too effortful and the resulting increase in generic memories reflects reduced central executive function. The hypothesis that the retrieval of specific autobiographical memories is an effortful process is explored in experiment 6 by combining the cue word autobiographical memory task with a measure of central executive function; the random generation task.

As Baddeley (1986) suggested that the task of generating random sequences of letters and numbers can be considered a paradigmatic example of a task requiring high levels of control and co-ordination, it can also act as a suitable secondary task for identifying central executive involvement in the retrieval of autobiographical memories. It is also proposed that generating random number sequences and attempting to recall past events share common features in terms of setting up retrieval plans and monitoring output. Both processes can be regarded as functions of the central executive competing for similar resources.

It is predicted that the retrieval of specific autobiographical memories will be more effortful than the retrieval of general memories and that the use of degraded (low imageable cues) will render the task of retrieving specific memories even more effortful. In the following studies the use of a non verbal form of a random generation task is explored as a secondary task to identify central executive involvement in the retrieval of autobiographical memories where both tasks are performed concurrently. Any decrement in randomness is taken to reflect the amount of effort devoted to the retrieval processes in all memory trials. As random number generation is regarded as a paradigmatic test of central executive function, the following chapter reviews the concept of randomness. Experiment 5 reported in Chapter 9 examines different measures of randomness and compares the sensitivity of such measures in random sequences generated by computer, published tables and humans.

Chapter 9

Random Number Generation

The ability of subjects to generate random sequences of numbers is central to the secondary task paradigm employed in the following four experiments. This process is complex and involves a number of different aspects of cognitive function. It has also been argued that no single measure can capture the complexity of randomness. This chapter explores the concept of random generation and reviews previous studies employing this task. A study to examine a number of different measures of randomness is also described.

The most commonly cited definition of randomness was reported by von Mises (1928/1957), for whom "a sequence of events was random, if in an infinitely long series the relative frequencies of the various attributes possess limiting values and if these limiting values remain the same in all infinite sub sequences selected by an arbitrary rule" (Mises 1957 pg. 128). Basic biases in subjective perceptions of randomness were discovered by early production tasks. Wagenaar (1972) reviewed a number of studies of randomness many of which were quite unsystematic. The number of alternatives varied from 2 (e.g. heads and tails, digits, card suits) to 26 (letters) produced in from 1 to 16 series per subject, lengths from 20 up to 2,520 each. Mode of production (e.g. writing calling out) as well as speed (from no limitation to 4 per second) and other factors varied across the studies. Furthermore a range of different measurements for non randomness were employed for these studies.

In spite of the variety of tasks and measures used, three fairly robust findings emerged from these studies. The first is a tendency to favour certain symbols with subjects selecting the different possible responses with unequal frequencies. The second is a bias to avoid repeating the same symbol or a preference for alternation (Bakan 1960; Rath 1966; Skinner 1942, Wagenaar 1970b). The third is a tendency to produce symbols in their ascending or descending natural ordering Rath (1966) and Wagenaar (1972).

It is a widespread belief that randomness excludes immediate repetitions, and Evans (1978) similarly noted that subjects tend to avoid immediate repetitions in random production. Another difference between actual randomness and common concepts of randomness appears to be that the common concept identifies randomness with evenness or balancing whereas actual randomness events approach evenness only after very long sequences. This is typified by reactions to lotteries where people tend to think "there have been a lot of drawings without a three, therefore a three has to come up soon". Thus, humans produce sequences that have too few symmetries and long runs, too many alternations among events and too much balancing over short regions (Lopes & Ogden, 1987).

Local Representativeness - a heuristic.

This balancing over short regions is also called the local representativenss effect (Kahneman & Tversky, 1972). These closely related effects have been found to extend up to the sixth order of dependency and are regarded as essentially cognitive biases, and as such have direct counterparts in judgement tasks. According to Kahneman and Tversky (1972), people judge the probability of events by the extent to which they represent the essential characteristics of their generating source. They also believe in a " law of small numbers," namely they believe small samples to be representative. Combining these two yields the simplest and most intuitive account of subjective randomness, that of local representativeness. By this account, when asked to judge which of a set of sequences is the most random, people look to see which captures the essential features of the random generating device the best. In the case of a fair coin, say these features are the equiprobability of the two outcomes, along with some irregularity in the order of appearance; these are expected to be manifest not only in long runs but also in relatively short segments - as short as six or seven.

The flaws in people's judgements of randomness in the large is the price of their insistence on its manifestation in the small. Kahneman and Tversky (1972) thus demonstrate that people rely on a representativeness heuristic to answer questions about random events. This heuristic refers to a general tendency for people to judge the subjective probability of an event by the degree to which it (a) is similar in essential characteristics to its parent population and (b) reflects the salient features of the process that generated it.

Lopes and Oden (1987) examined peoples ability to judge accurately whether strings had been generated by random or non random processes. Subjects were a) not informed about the non random process, b) informed about the qualitative nature of the process or c) given accurate feedback after each trial about the generating process. Results show that subjects equate long runs and symmetry with non randomness, and high rates of alternation with randomness making them less successful in detecting alternation biased processes. These findings are consistent with earlier studies (Wagenaar ,1972). The data also shows that performance can be improved by accurate feedback or instructions.

Previous research has suggested that ordinary experience with random processes is insufficient for people to acquire adequate conceptions of randomness (Kahneman & Tversky, 1972; Slovic, Kunreuther and White, 1974). The results of Lopes & Oden (1987) however show that performance in signal detection tasks can be improved quite easily with feedback about which process generated the just judged string. In fact feedback appears to function more effectively than instruction in eliminating the tendency of participants to alternate while generating random sequences.

The role of feedback and learning in random generation.

Although people's productions have failed many different types of tests of randomness, suitable training and feedback can apparently teach them to overcome the biases which they tend to exhibit. The most thorough and ambitious study of this kind was carried out by Neuringer (1986). Subjects in the experimental condition were given feedback on the output generated of 60 series of 100 binary responses. These feedback sessions were continued as long as was necessary for a subject to reach a criterion of 60 consecutive series, none of which deviated significantly from the computer generated random series. Results showed that two of the four trained subjects passed all eight tests of randomness (binomial tests, one sample runs, some chi square tests and autocorrelations), tests that naive subjects typically fail. Thus, with feedback, subjects can learn to produce random sequences that are statistically indistinguishable from computer generated sequences. However, subject's learning was not permanent in that performance deteriorated as soon as feedback was discontinued.

Neuringer (1986) offers two different explanations to account for the process of randomness; explanation by trait and explanation by skill. An explanation by trait implies that because of inherent limitations people are incapable of random behaviour. Such an explanation depends upon the fact that in a random series, responses must occur with approximately equal frequencies over the long run. Memory capacity has been postulated as one limiting factor in the generation of random sequences by humans. Another view is that attentional processes do not permit subjects to completely ignore their previous responses, an inattention necessary according to this view for random behaviour (Weiss 1964). A third hypothetical limitation derives from subject's difficulty in conceptualising randomness. When presented with two series of numbers, subjects sometimes cannot discriminate random from non random series (Wagenaar 1970b).

A number of different strategies used by people in random generation have been identified by Spatt and Goldenberg (1993). Typically subjects are instructed to produce sequences by any procedure available, and to monitor whether the produced sequence concurs with the subject's concept of randomness. However there are three possible limitations to the execution of this strategy including limited availability of production policies. When subjects notice that the sequence they produce deviates from randomness, they must immediately change to another production policy. Success of this strategy however depends on the number of procedures available and on the ease of shifting from one action scheme to another. Baddeley (1986) suggests that in generating random sequences of letters, subjects tend to rely on over learned procedures like reciting the alphabet, or stereotyped responses and the use of common acronyms (e.g. BBC, FBI). The prevalence of these responses tend to increase in dual task conditions where there is less capacity available to monitor output.

Given the well established limitations of verbal short term memory, only sequences of less than 10 items can be kept in working memory. Thus, subjects should be able to monitor the evenness of occurrence of single digits, provided that there are no more than 10 to select from. By contrast the capacity of working memory is unable to monitor the distribution of pairs of digits. Spatt and Goldenberg (1993) applied first (RMI) and second order (RM2) measures of redundancy to calculate the evenness of distribution of single letters or numbers and that of pairs respectively. The RM2 is identical to Evans (1978) index of randomisation. This index measures the difference between expected and observed probabilities of pairs of digits.

Comparing random generation by normal subjects with that of computer generated sequences shows that the results are compatible with the predictions of how human generation differs from true randomness. There were highly significant differences for all indices. Human subjects keep the distribution of single digits more even than the computer simulation and avoid immediate repetitions of digits. Their capacity to monitor the evenness of distribution of pairs is worse than that of the computer (RM2) and they make more use of counting.

The overall aim of the study by Spatt & Goldenberg (1993) was to establish measures of random generation based on theoretical assumptions about the nature of human random generation and to separate different qualitative aspects of human impairment in this task. Patients with dysexecutive syndrome and Parkinson's Disease were compared with a control matched group for their ability to generate a sequence of random numbers. Human random generation is based and guided by the subject's concept of randomness. That most peoples concept of randomness deviates from true randomness is reflected in the avoidance of immediate repetitions.

In order to maintain randomness there has to be monitoring of the sequence already uttered. According to Spatt & Goldenberg (1993) subjects succeeded in doing this judging from the distribution of single digits (RMI) but not for pairs of digits (RM2). There has to be rapid changes between different production policies to approach randomness in the production of sequences of digits. Counting constitutes the major source of enhanced non randomness in patients with frontal lobe damage or with Parkinson's disease. An incapacity to perform rapid changes between production schemata appears to be the main source of impaired random generation in these patient groups.

Thus the findings of Spatt & Goldenberg (1993) are consistent with the assumption that the cognitive deficits of the patient group are due to impaired control of the Supervisory Attentional System (SAS) (Norman & Shallice 1980, Shallice 1988). The SAS intervenes only by changing the activation levels of the various schemata. Random generation as a process puts continuous demands on the SAS as activation of the currently used scheme has to be suppressed each time when disturbance of the concept of randomness is observed. Sophisticated algorithms similar to those implemented in computer simulations which produce apparently random sequences by a simple strategy are beyond the capacity of human subjects.

Measurements of Randomness.

The generation of random number sequences as a measure of attention deployment has been limited due to the lack of a satisfactory index of pseudo randomness for relatively short response sequences (Wagenaar 1972). A difficulty confronting previous investigators has been the multiplicity of often inadequate criteria for measuring the degree of subjective randomization in a reasonably short response series. A new index of subjective randomization (RNG) was proposed by Evans (1978) that provides a sensitive measure of departures from randomness, in a series as short as 100 responses typically verbalised at the rate of 1/sec. The RNG index of sequential response bias is a minor modification of Tulving's (1962) subjective organization index that measures clustering in the repeated free recall of randomly presented word lists. The method described appears to have several advantages. There are no apparent repeated performance practice effects; neither the subject nor the experimenter can easily evaluate how well the typical subject is performing; a stable index can be derived from a series as short as 100 numbers. The full calculation of this index is described in Appendix D.

The guiding hypothesis is that random number generation may provide a sensitive index of change in the deployment of attention over short intervals of time or the amount of attentive effort that is expended during a simultaneous task. The index of randomness selected is a measure of sequential response bias. The randomization index reflects the disproportion of sequence pairs within the cells adjusted by the disproportion of the marginal cell frequencies. It has a range of values from 0.0 to 1.0. A higher index reflects more extreme departures from the theoretical expected values - that is it indicates poorer randomization.

It is generally agreed that individuals are not good random generators. Hypotheses advanced to account for the individual differences in the ability to randomize have stressed faulty concepts of randomness (Skinner 1942), the inhibiting effects of short term memory, and limited capacity for information processing. Rosenberg, Weber, Crocq, Duval, and Macher (1990) have argued that no single parameter can adequately capture the complexity of this task and it is possible that combining measures of randomness increases sensitivity. The following study describes a number of these different measures and compares the generation of random sequences by humans, computer programs and sequences found in published tables.

Generation of Random Sequences by Human Subjects, Tables, and Computers.

Experiment 5.

When subjects are asked to generate random sequences, they normally cannot produce sequences that satisfy accepted criteria for randomness Certain findings recur. The first is a tendency to favour certain symbols and subjects select the different possible responses with unequal frequencies. The second is a bias to avoid repeating the same symbol or a preference for alternation). The third is a tendency to produce symbols in their ascending or descending natural ordering

Rosenberg (1990) compared randomization performance of fifty sequences of random numbers generated by computer and compared with those sequences produced by a control group of subjects, a schizophrenic group and an alcoholic group. The measures of randomization used by Rosenberg included the following variables, phase, triplets, Evans Randomization Index, Mean difference and Chi Square. The randomization performance of the computer was significantly better than the control group as measured by all randomization indices apart from Mean Difference. This study uses 20 sequences of random numbers (N= 100) generated by subjects, and computer and also from published tables.

Method

The purpose of this experiment was to compare the generation of random sequences from four different sources; using human subjects, published tables and two versions of computer generated sequences. The latter included sequences generated using a Q-Basic program and a current algorithm described by Marsaglia, Zaman & Tsanh (1990). For each of the four source categories, 20 sequences of random sequences consisting of 100 numbers were collected. Subjects random sequences were collected as part of another experiment whereby subjects were required to press keys numbered 1-10 randomly in response to a tone sounding at 1 second intervals. It was predicted that human subjects would produce significantly less random sequences than the other sources. No prediction was made as to which measure would be the most sensitive.

Measures of randomness

The numerical measures of randomness used in this study are explained below;

1. Phase (P) This statistic is the number of increasing or decreasing runs or sequences of numbers ignoring the first and last runs. For the following sequence (1);

2,3,4,2,5,7,3,1,2,3,4,2,

the phase is P= 4. Subjects who produce poorly randomised sequences often have a tendency to count up or down and so produce fewer runs than normal, whereas high phase values reflect truly randomised sequences. Low phase values reflect poorly randomised sequences.

2 Triplets (T) . This is defined as three consecutive numbers. The statistic TRIPLETS is the number of triplets that appear only once in a sequence. In the example sequence above (1) ten triplets can be extracted from the sequence of 12 numbers;

(2,3,4) (3,4,2) (4,2,5) (2,5,7) (5,7,3) (7,3,1) (3,1,2,) (1,2,3)
(2,3,4) (3,4,2)

but the number of unique TRIPLETS that appear only once in the sequence = 6, as (2,3,4) and (3,4,2) are repeated. The higher the number of triplets, the less repetition there is in the sequence and consequently the greater the randomness. A low triplet score implies low randomness.

3 Mean Successive Difference (MD). This statistic reflects to some extent the tendency to count in the series. If there is a counting trend such that P is small then the mean difference will also be small because successive differences will tend to be smaller than those generated by a random sequences.

4. Pearson's Chi Squared Statistic (x squared)

This statistic looks at the frequency with which each number occurs in the sequence and reveals little about the dependence structure in the sequence. It does however detect those subjects who preferentially select certain numbers. This statistic is closely correlated with Baddeley's % Redundancy measure (1966) as both indices are looking at the frequency of individual responses.

5. Randomisation Index (Evans 1978)

This index was chosen by Rosenberg et al (1990) to enable them to compare their results with those of Horne et al (1982) as RI or (RNG) was the only measure used in the latter study. Evans (RNG) index is a lower order measure of randomisation than TRIPLETS and is based on pairs rather than on triplets. Values of RNG ranges from 0 and 1 with purely random sequences producing RNG values close to 0. Both the RNG index and TRIPLETS are expected to be negatively correlated because as the number of unique triplets increases the number of number of unique pairs increases and the RI decreases in turn.

6. Autocorrelation Index ACI

This gives a measure of the area between the correlellogram and the abscissa and is a statistic borrowed from time series analysis in that it is very similar to Box-Pierce statistic. If the sequence is truly random then ACI would be expected to be small (about 2.8) however if there is counting or cyclical behaviour then the ACI would be much larger.

Results.

The mean values and standard deviations of all measures of randomness for all source groups are shown in Table 9.1. A series of one way factorial ANOVAs were performed on all the random sequences generated by subjects, published tables, and two computer generated sources for all 6 measures of randomness.

Chi-Square: There were no significant differences between the 4 groups across this measure $F(3,76) = 0.59$, $MSe = 45.16$, $p > .05$.

ACI: Similarly there were no significant differences between groups for this measure F (3,76) = 1.12, MSe = 0.35, p >.05

Mean difference: No significant differences were found between the 4 groups across this measure of randomness F (3,76) = 2.34, MSe = 0.01, p >.05

Phase: Analysis of this variable did show a significant difference between groups F (3,76) = 4.41, MSe = 30.14, p<.01. Post hoc tests (Newman Keuls) confirmed significant differences between Q basic computer simulations, the Marsaglia et al algorithm and those sequences generated by human subjects, (p<.05) The randomness of sequences generated by human subjects as measured by phase values was greater than the remaining groups. No significant differences were found between random sequences generated by humans and those obtained from published tables.

Evans RNG: A significant difference was found between groups for this variable F (3,76) = 20.13, MSe = 0.01, p <.001. Post hoc tests (Neuman Keuls) show significant differences between this index for the human sequences and the other 3 sources of randomness, (p<.05) The mean RNG value for humans was .299 which suggests that this sequence was significantly less random than the remaining sources.

TRIPLET: A significant difference was also found between groups for this variable, F (3,76) = 12.60, MSe = 38.68,p <.001. Post hoc tests (Neuman Keuls) demonstrated significant differences between human generated sequences and those obtained from published tables and computer programs (p<.05) suggesting that the human generated sequences were less random.

The means and standard deviations of all measures of randomness for all groups are shown in Table 9. 1. Data from Rosenberg et al (1990) study are also included for comparisons.

Table 9.1

Mean Values of randomization indices for groups studied and a comparison with those of Rosenberg et al (1990)

Group	P	T	MD	RNG	ACI	Chi Sq.
Q-Basic	59.45 (4.1)	89.75 (4.7)	4.10 (0.3)	.244 (.02)	3.2 (0.5)	8.38 (3.2)
Marsaglia	60.10 (4.9)	87.75 (4.8)	4.10 (0.3)	.242 (.02)	3.2 (0.5)	8.41 (3.3)
Tables	61.95 (4.2)	88.40 (4.8)	4.13 (0.2)	.233 (.02)	3.3 (0.6)	7.58 (5.3)
Subjects	65.20(7.8)	78.90 (9.3)	4.30 (0.3)	.299 (.02)	3.5 (0.6)	10.30(11.5)
Rosenberg (C)	59.30 (5.0)	88.90 (4.4)	4.00 (0.2)	.242 (.02)	3.0 (0.4)	not tested
Rosenberg (S)	54.90 (7.5)	78.20 (7.0)	3.80 (0.4)	.308 (.04)	3.9 (0.9)	not tested

Key: P = phase measures, T = triplet measures, MD = mean difference, RNG = Evans Index , ACI = autocorrelation index,.(C) refers to the computer generated sequences used by Rosenberg and (S) refers to the subject group .

Discussion.

This study aimed to examine differences in randomness between 4 sources commonly used to obtain random sequences. These sources or categories were random sequences generated by subjects, published tables of random numbers, computer simulated sequences produced by a Q -Basic program and a modified algorithm of random sequences production described by Marsaglia & Zaman (1990). The results suggest that humans randomise less well than do computer generated sequences consistent with their subjective concept of randomness but findings also suggested that not all measures of randomness were sensitive to these differences.

Randomness was measured using 6 parameters, Chi square, Mean Difference, Auto Correlation Index, Evans RNG, Triplets and a Phase measure. The randomization performance of both computer programs and those of random published tables was significantly higher than the experimental subject group as measured by the following randomisation indices; Evans RNG and the triplet statistic. No significant differences were obtained on the randomness of sequences generated by computer and those obtained from published tables.

Evans randomization index is a measure of sequential response bias and reflects the disproportion of sequence pairs within the cells. It has a range of values from 0.0 to 1.0. A higher index reflects more extreme departures from the theoretically expected values, that is it indicates poorer randomization. The finding that human subjects' randomness was significantly less when measured using this parameter when compared with the other groups is consistent with that of Rosenberg et al (1990). Randomness of the sequences generated by human subjects was also significantly less than the comparison groups when randomness was measured by a Triplet statistic. This result is also consistent with the findings of Rosenberg et al (1990) when comparing random sequences from different sources using similar statistics.

The third significant variable was Phase (P) measurement. This statistic is the number of increasing or decreasing runs or sequences of numbers. Subjects who produce poorly randomised sequences often have a tendency to count up or down and so produce fewer runs than normal. However in our study, subjects produced a significantly higher phase value than the other groups, which would imply that their randomness was greater than computer versions or tables using this measure. This result is counterintuitive as previous studies have demonstrated that when human subjects generate random numbers they have a tendency to produce symbols in ascending or descending natural order. In this instance subjects appeared to produce shorter runs of such sequences so maximising randomness. This finding is also inconsistent with Rosenberg et al (1990) who demonstrated that subjects produced less phase runs than computer simulations. One possible explanation may be the fact that subjects were using a keyboard to generate sequences and that this ensured that they rapidly switched between ascending and descending runs.

There were no significant differences in randomness between the four source groups, when randomness was measured by Chi Square, Mean Difference or Auto Correlation Index. Rosenberg et al (1990) similarly found that MD was an insensitive measure. This data does however confirm results obtained by Rosenberg et al (1990) and Spatt & Goldenberg (1993) when second and third order measures of redundancy as measured by Evans randomization index and the triplets statistic are considered. Different possible responses are

Chapter 10

Random Generation and Central Executive Function.

Experiment 6 (a)

The literature reviewed in chapters 8 and 9 showed that the task of random generation had proved to be a useful one as a measure of central executive function. Its sensitivity to executive capacity arises because the process of random number generation requires the participant to produce a response that is ever changing. Any tendency to repeat the same response will reduce the randomness of that particular sequence length. Such a process requires vigilant monitoring of output, by requiring central executive resources to prevent repetitions.

The following experiments use Baddeley's (1996) random keyboard generation task. This version of the random generation has been described in detail in Chapter 9. Having participants generate random sequences using a keyboard greatly increases the scope of random generation as a secondary task. It can be combined with a primary task such as the retrieval of autobiographical memories in response to cue words and secondly using keyboard generation means that responses are directly entered into a computer which facilitates subsequent analysis.

The first experiment reported in this chapter aimed to test whether this keyboard version of the random generation task is a measure of working memory capacity and sensitive to variation in processing loads. Participants are given an immediate verbal memory task which consists of digit sequences varying in length from two to eight digits. This primary task is performed singly and then concurrently with the random keypressing task. The randomness of the keypresses should vary systematically with increased memory loading, if the task does reflect central executive processing.

Also combining an auditory memory span task with the visual keypressing task allows us to test whether the random keypressing task is modality specific. If this is the case then no interference should be found between the memory span task and the randomness of the keypressing task. If however the random keypressing task in not modality specific, and does reflect the operation of a limited capacity general working memory system, both tasks should interact. Thus, a heavier processing load such as an eight digit sequence should result in a systematic reduction in the randomness of responses concurrently generated, and combining the digit span task with the random generation task should also affect performance on the primary digit span task. It is important to demonstrate that any effects are not modality-specific since later studies aims to combine the random keypressing task with an autobiographical memory task which also involves different modalities (visual/motor in the case of the keypressing task and auditory/verbal for the autobiographical memory task).

Method

Subjects. There were twenty six participants in this experiment; 19 females and 7 males ranging in age from 18 to 45 years. They were recruited from the undergraduate subject pool at the University of Wales Bangor.

Materials. A specially constructed keyboard was used to run the random keypressing task. This keyboard measured 57 cm x 70 cm and contained two groups of five keys, one for each hand. The keys were 2cm wide and 1.3cms apart. The keyboard was connected to a Mackintosh Classic 11 which recorded each keypress. The keys were numbered 0 - 9 inclusive.

Design A 4 (sequence length - 2,4,6,8) x 2 (conditions - single and combined) within subjects design was used in the immediate verbal memory task.

Memory Span task.

This task was an immediate verbal memory task consisting of digit lists which varied from 2 to 8 digits. There were 4 trial conditions 2, 4, 6, 8, and participants were requested to recall the different lists of digits. This task was performed singly and concurrently with the secondary task of random keypressing.

Measure of Randomness.

As an index of the randomisation of the 100 digits generated using the keyboard, Evans (1978) index of randomisation (RNG) was calculated. This measure of randomness was adapted from Tulving's (1962) subjective organization index of clustering in free recall and takes account of overuse of repeated pairs of sequences of digits. Responses are entered into a 10x10 matrix reflecting the frequency with which any digit follows any other digit in 100 consecutive responses. The (RNG) index can range in value from 0 to 1. Evans (1978) reported mean RNG from a number of samples of subjects based on 100 numbers produced at the rate of one per second as .300 (SD = .045). Higher RNG values correspond to low level of randomness. The previous experiment (5) has also confirmed that this measure of randomness is a sensitive measure.

Procedure.

The testing session began with an explanation of randomness followed by a brief practice at generating single key-responses using the keyboard.

Participants were given the following instructions;

> " You may be familiar with the concept of randomness. For example, if you were to throw a dice many times, each of the six numbers on the dice would occur in random sequence. Similarly if you imagine that there is a hat in front of you containing these keys numbered 0 - 9, and that you select a key one at a time and call out the number. That key is replaced in the hat and this procedure repeated until 100 random numbers have been called. Your task is to press the numbered keys in a similar random fashion, in response to a tone that the computer makes. You must try to pace your responses with the tone. If you should find yourself ahead or behind the tone just try to get into pace with it again. Remember that 0 is a real number and use the full range of keys from 0 - 9 inclusive"

This explanation and instruction was followed by a brief practice generating single keypresses at the rate of one every second using the keyboard. This was followed by practice trials with each of the 5 digit memory loads. In this task the following instructions were given;

> " I will be calling out different lists of numbers to you. Some of these lists contain 2 digits, others have 4 , 6 and 8 digits. I will call out these digits to you and your task is to repeat the digits back to me at the same rate .
> For example take the 4 digit case, I will call out 7,1,4,9, and you repeat those numbers back to me. If you are unable to recall a number just say blank"

This procedure was repeated continuously until all 4 conditions had been completed. Participants were also requested to perform the memory span task at each sequence length with concurrent keyboard generation in order to assess the influence of random generation on memory, and a brief practice session was also included. A baseline trial was also completed whereby participants performed the random keypresssing task alone. Participants were given single trial blocks of 100 seconds on each task and the procedure repeated continuously until all sequence lengths were completed.

Results.

Memory Span Task.

The means and standard deviations of each digit span (0,2,4,6,8,) when performed alone and with the concurrent keypressing task are shown in Table 10.1 . In the immediate verbal memory span task, Figure 10.1 shows the mean percentage of correct sequences as a function of sequence length and whether the task was performed alone or combined with concurrent keyboard pressing. A 4 (sequence length) x 2 (conditions- single or combined)ANOVA was performed. There was a highly significant effect of sequence length, (F (3,75) = 109.39, MSe = 426.20, p<.001) and in addition a significant effect of trial condition (F (1,25) = 20.68, MSe = 96.96, p <.001).

This suggests that the concurrent performance of generating random keypresses impaired memory performance. A significant interaction between sequence length and trial condition was also found (F, (3,75) = 5.42, MSe = 108.37, p<.01). This is most likely due to the presence of ceiling effects for sequence lengths 2 and 4 which masks any possibility of observing an effect of condition at these lengths. Planned comparisons show a significant difference between the 6 digit span conditions performed singly and when combined with concurrent keypressing (p<.01). A significant difference was also shown between the 8 digit span conditions (p<.01). There were no significant differences between the 2 and 4 digit spans (p> .05) in each case.

Results.

Memory Span Task.

The means and standard deviations of each digit span (0,2,4,6,8,) when performed alone and with the concurrent keypressing task are shown in Table 10.1 . In the immediate verbal memory span task, Figure 10.1 shows the mean percentage of correct sequences as a function of sequence length and whether the task was performed alone or combined with concurrent keyboard pressing. A 4 (sequence length) x 2 (conditions- single or combined)ANOVA was performed. There was a highly significant effect of sequence length, (F $(3,75) = 109.39$, $MSe = 426.20$, $p<.001$) and in addition a significant effect of trial condition (F $(1,25) = 20.68$, $MSe = 96.96$, $p <.001$).

This suggests that the concurrent performance of generating random keypresses impaired memory performance. A significant interaction between sequence length and trial condition was also found (F, $(3,75) = 5.42$, $MSe = 108.37$, $p<.01$). This is most likely due to the presence of ceiling effects for sequence lengths 2 and 4 which masks any possibility of observing an effect of condition at these lengths. Planned comparisons show a significant difference between the 6 digit span conditions performed singly and when combined with concurrent keypressing ($p<.01$). A significant difference was also shown between the 8 digit span conditions ($p<.01$). There were no significant differences between the 2 and 4 digit spans ($p> .05$) in each case.

Table 10.1

Memory Span Task -% correct sequences with and without keypressing task

	Trial Condition	
Span	Single	Combined
Two	100	100
Four	99.76 (1.17)	99.11 (3.49)
Six	84.11(14.54)	70.58 (25.08)
Eight	42.42 (32.22)	29.61 (26.45)

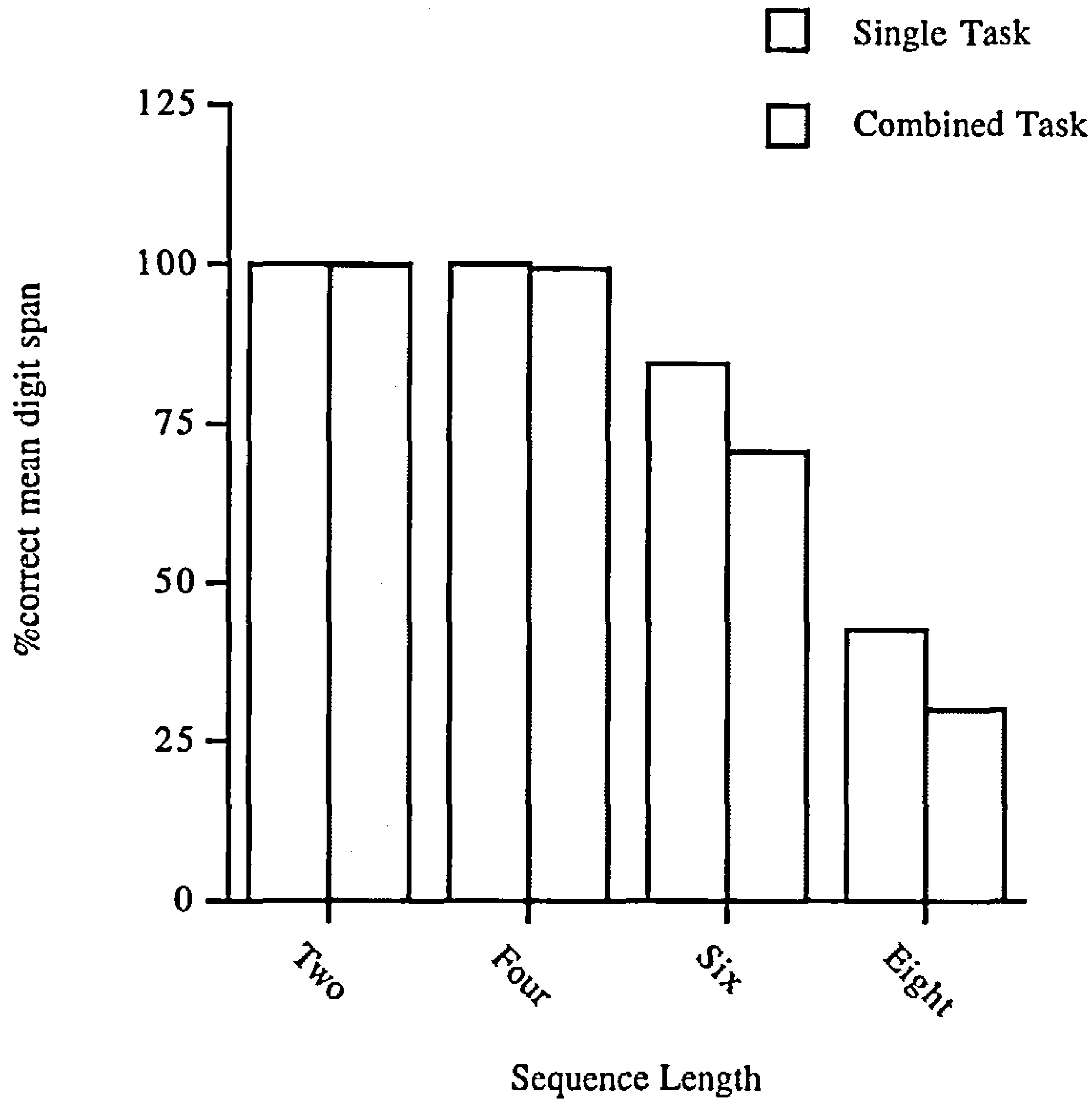

Figure 10.1 Immediate digit span task with and without the secondary task.

The effect of memory span task on Random Generation.

Evans index of randomisation (RNG) was used to calculate the randomness of all keypressing trials, and the effect of performing the digit span task combined with the secondary task is illustrated in Figure 10.2 The means and standard deviations of these measures are shown in Table 10.2 A one way analysis of variance (sequence length) with Evans RNG as the dependent variable showed a significant effect of trial condition ($F(4,21) = 7.41$, $MSe = .005$, $p < .001$). Planned comparisons show that the baseline condition was more random than the 2, 4, 6, and 8 digit conditions ($p < .01$). The 2 digit condition was also significantly more random than the eight digit condition ($p < .05$). There were no significant differences in randomness between the other digit conditions, ($p > .05$).

Table 10.2

Means and S.D. of Evans RNG measure of randomness at baseline (no memory task) and at different digit span conditions.

		Memory Span			
	Baseline	Two,	Four	Six	Eight
RNG	.318 (.06)	0.373(.07)	0.387 (.10)	0.400(.14)	0.418 (.08)

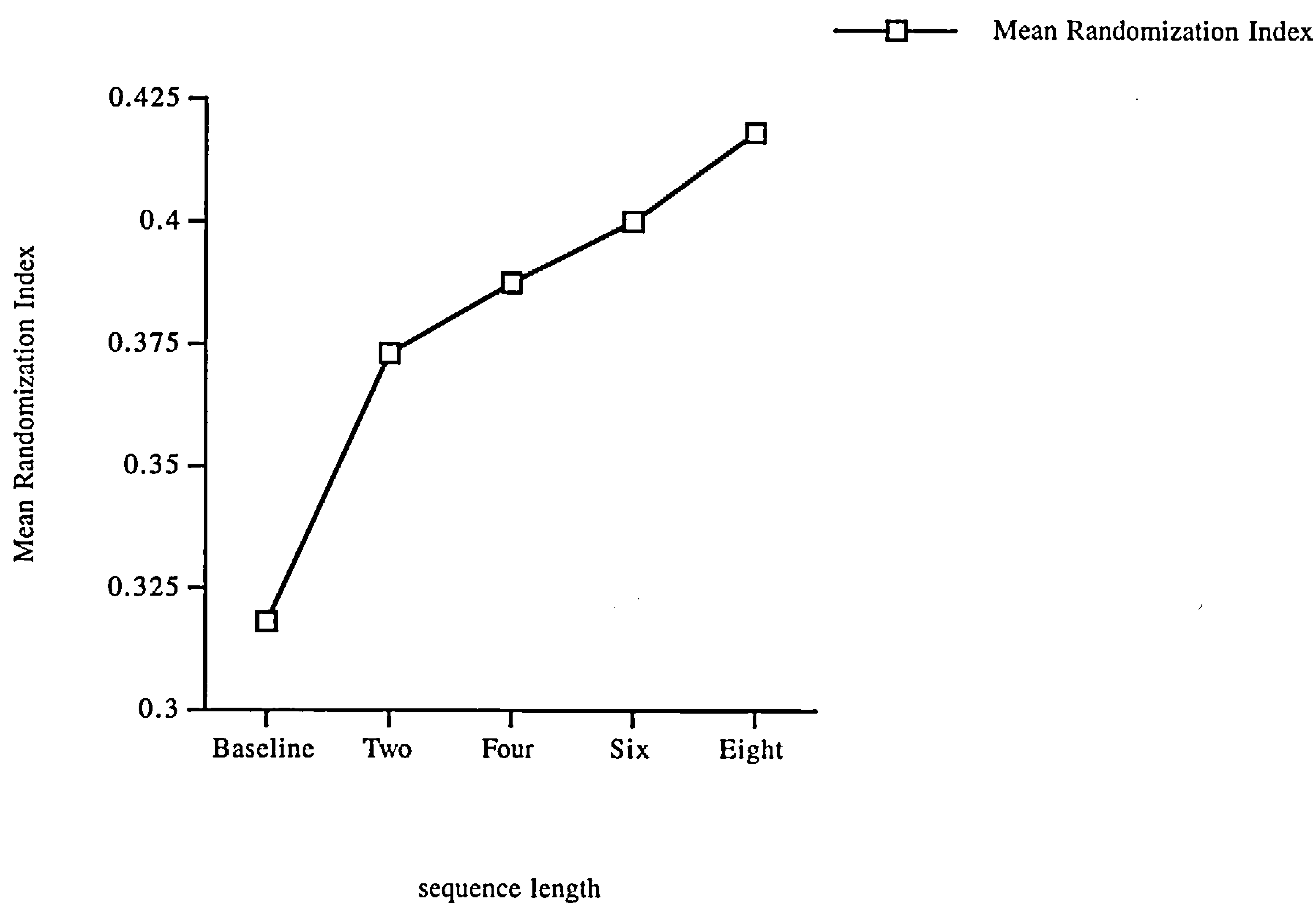

Figure 10.2. The effect of concurrent digit span task on the randomness of keypressing

Omission analysis - digit span task

Since there was a large number of omissions where participants failed to press the keys each time a beep sounded, an analysis of the percentage of omissions across the memory span task and autobiographical memory trials was computed. It is possible that the variation in omissions would be a further indicator of information load. The number of occasions which participants failed to press a key in response to a tone were calculated as a % omission across all digit span trials for 22 participants. (2 participants who had high % omissions in their baseline measures and 2 participants whose % omissions exceed 50% in 2 and 4 digit conditions were excluded from this analysis).

The means and standard deviations of the % omission scores which occurred when participants performed the digit span task are shown in Table 10.3. A one way analysis of variance was computed across 5 digit span trials with % omission as the dependent variable. A significant effect of trial condition was shown ($F(4,21) = 13.48$, $MSe = 47.19$, $p < .001$). Planned comparisons show that the % omission was significantly higher as the digit load increased with the highest amount of error recorded in the 8 digit condition. There were significant differences between the number of omissions that occurred when subjects were recalling sequences of 8 digits compared to the other 2, 4, and 6 digit conditions ($p<.01$). There were also significant differences between the 6 digit condition and the 2, and 4 digit trials ($p<.01$). The two latter digit conditions were not significantly different, ($p>.05$).

Table 10.3

Means and S.D. of % omission scores in the digit span task

	Memory Span			
Baseline	Two	Four	Six	Eight
% omissions				
1.45(2.2)	7.54(8.7)	6.70(9.9)	12.60(10.3)	15.22(9.6)

Discussion

The aim of this experiment was to investigate a modified non verbal version of Baddeley's (1966) random generation task. To ensure that this version of the traditional random generation task is a reliable and sensitive measure of working memory capacity, the task should be sensitive to variation in information or processing load. An immediate memory span task was used to assess the sensitivity of the keyboard random generation task.

The results are consistent with the hypothesis that random key pressing reflects the operation of a central executive of a limited capacity general

These omissions however may also have affected the sensitivity of the digit span task. The effect of performing the digit span task did disrupt the randomness of the keypressing task with significant differences shown between the baseline and the 2,4,6, and 8 digit condition. The randomness of keypressing when participants were recalling 2 digits was significantly greater than in the 8 digit condition. While these results strongly suggest that the keypresssing task is indeed sensitive to large variations in processing capacity, it does suggest that it may be somewhat insensitive to more subtle differences in load. A possible reason for this is that participants were asked to generate 1 keypress per second in response to a tone and that many participants did not press the keys each time resulting in variable data sets for analysis.

Evans (RNG) index of randomisation is specifically designed for 100 numbers and because of the variation in the data sets used for randomness analyses where the number of these sets varied from 100 to 70 keypresses across all trials it is necessary to repeat this experiment. To ensure that the keyboard version of the random generation task is a reliable and sensitive measure of processing capacity or information load and does reflect the effort needed for the primary task, the following modifications are included in the next experiment 6 (b). The number of times where participants are requested to press the keys in response to a tone is increased to 130 times thus allowing for omissions and ensuring that all data sets for randomness measures will equal 100. Secondly to minimise practice effects on the keypressing task, an additional factor of sequence order is included in the digit span task. Half the participants will commence in an ascending order (2, 4, 6 ,and 8) and the other half in descending order (8,6,4,2).

The Sensitivity of the Random Generation Task

Experiment 6 (b)

The purpose of this experiment is to ensure that the non verbal version of the random generation task is sensitive to processing or information load. While the results of study 6 (a) would suggest that the keyboard random generation task is sensitive to large variations in processing loads, this experiment aims to replicate that study with the additional modifications previously described incorporated.

Method

Subjects. Twenty participants were recruited from the Undergraduate subject panel of University of Wales, Bangor, Department of Psychology. They comprised 16 females and 4 males and the mean age was 29 years.

Materials. A specially constructed keyboard was similar to that in Experiment 6 (a) used to run the random keypressing task. This keyboard measured 57 cm x 70 cm and contained two groups of five keys, one for each hand. The keys were 2cm wide and 1.3cms apart. The keyboard was connected to a Macintosh Classic 11 which recorded each keypress. The keys were numbered 0 - 9 inclusive.

Design. A 5 (sequence length 0 ,2,4,6,8,) x 2 (condition; single or combined) x 2 (sequence order; ascending or descending) mixed factorial design was used. Both sequence length and trial conditions were within subject factors while sequence order was a between subject factor. Half of the participants performed the digit span task given ascending sequences (2,4,6,8) while the other half were given descending sequences (8,6,4,2,).

Memory Span task.

This task was an immediate verbal memory task consisting of digit lists which varied from 2 to 8 digits. There were 4 trial conditions 2,4,6,8, and participants were requested to recall the different lists of digits. This task was performed singly and concurrently with the secondary task of random keypressing.

Measure of Randomness.

As an index of the randomisation of the 100 digits generated using the keyboard, Evans (1978) index of randomisation (RNG) was calculated

Procedure.

The same procedure was followed as in experiment 6 (a). The testing session began with an explanation of randomness. This explanation was followed by a practice session with participants generating single keypresses at the rate of one every second at the keyboard. The digit span task was also similar to that used in the previous study. Participants were requested to perform the memory task at each sequence length with concurrent keyboard generation in order to assess the influence of random keyboard generation on memory. Practice sessions were completed at each sequence length. In the main experiment the sequence order of the digit span task was counterbalanced with half the subject group commencing the digit span task in ascending order (2,4,6,8) and the other half commencing in reverse order (8,6,4,2,). All participants were given single block trials of 130 seconds on each task and the procedure repeated continuously until all sequence lengths were completed.

Results.

The effect of concurrent keypressing task on memory span.

The means and standard deviations of correct digit spans are shown in Table 10.4. In the immediate verbal memory task, Figure 10.3 shows the mean percentage of correct sequences as a function of sequence length and of whether the task was performed alone or combined with concurrent key board pressing. A 4 (sequence length) x 2 (conditions- single or combined) x 2 (sequence order-ascending or descending) ANOVA was performed. There was a highly significant effect of sequence length $F(3,54) = 181.76$, MSe = 176.71, MSe = 217.05, $p < .001$ and in addition a significant effect of trial condition $F(3,54) = 26.07$, MSe = 57.60, $p < .01$, indicating that concurrent generation of random keypresses impaired memory performance. There was no effect of sequence order ($F < 1$).

A significant interaction between sequence length and trial condition was also observed $F(3,54) = 9.02$, MSe = 14.25, $p < .001$. This however is most likely due to the presence of a ceiling effect for sequence lengths 2 and 4 and thus masks any possibility of observing an effect at these lengths. Planned comparisons *show significant differences in recall between the 6 digit span condition when* performed singly and with concurrent keypressing ($p < .01$). Similarly there was a significant difference between the 8 digit single and dual task condition ($p < .01$). There were no other significant differences demonstrated.

Table 10.4

Immediate memory task with and without secondary keypressing task

	Trial Condition	
an	Single	Combined
vo	100	100
ur	99.85 (.67)	99.0 (1.62)
ĸ	90.35 (8.47)	82.35 (14.98)
ght	41.70 (25.27)	25.75 (19.17)

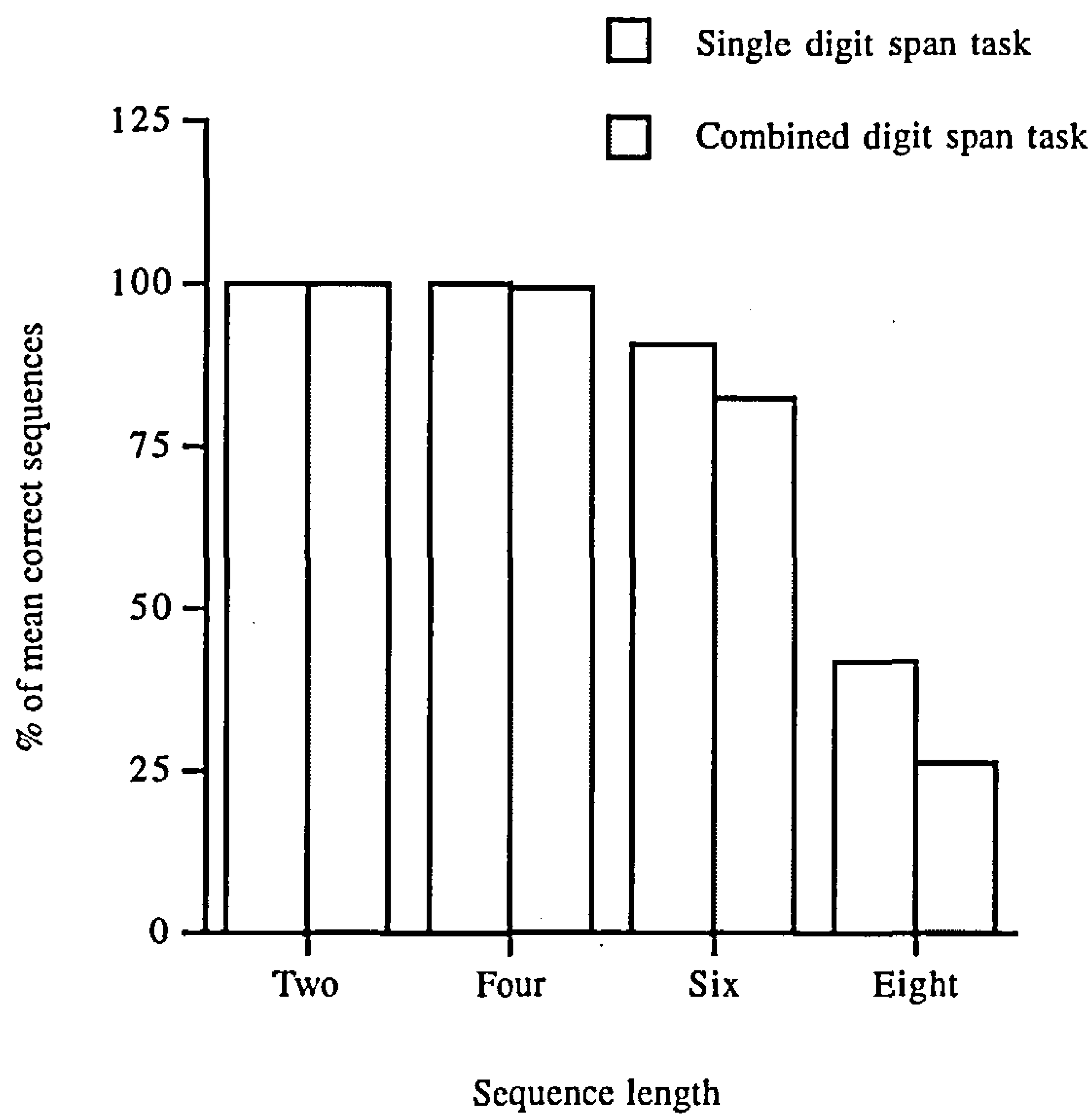

Figure 10.3. Immediate digit span task in single and dual task conditions.

The effect of digit span on random keyboard generation.

The means and standard deviations of concurrent digit span on the randomness of keypressing are shown in Table 10.5 and Figure 10.4. The influence of concurrent digit span on random keyboard generation was analysed in a one way analysis of variance incorporating the five memory task conditions 0,2,4,6,8. This demonstrated a clear effect of trial condition ($F_{(4,18)} = 14.03$, $MSe = .003$, $p < .001$). Planned comparisons between conditions indicated that the zero load condition was more random than the 4, 6, or 8 digit condition ($p < .01$). The two digit condition was more random then than 6 or 8 digits ($p < .01$), the 2, 4 digit and six digit were more random than the 8 digit ($p < .01$).

Table 10.5

<u>Means and S.D. of Evans RNG measure of randomisation at baseline (no memory task) and at different memory loads</u>

		Memory Spans			
	Baseline	Two	Four	Six	Eight
Evans (RNG)	.323 (.04)	.344 (.04)	.366 (.07)	.391(.08)	.435 (.10)

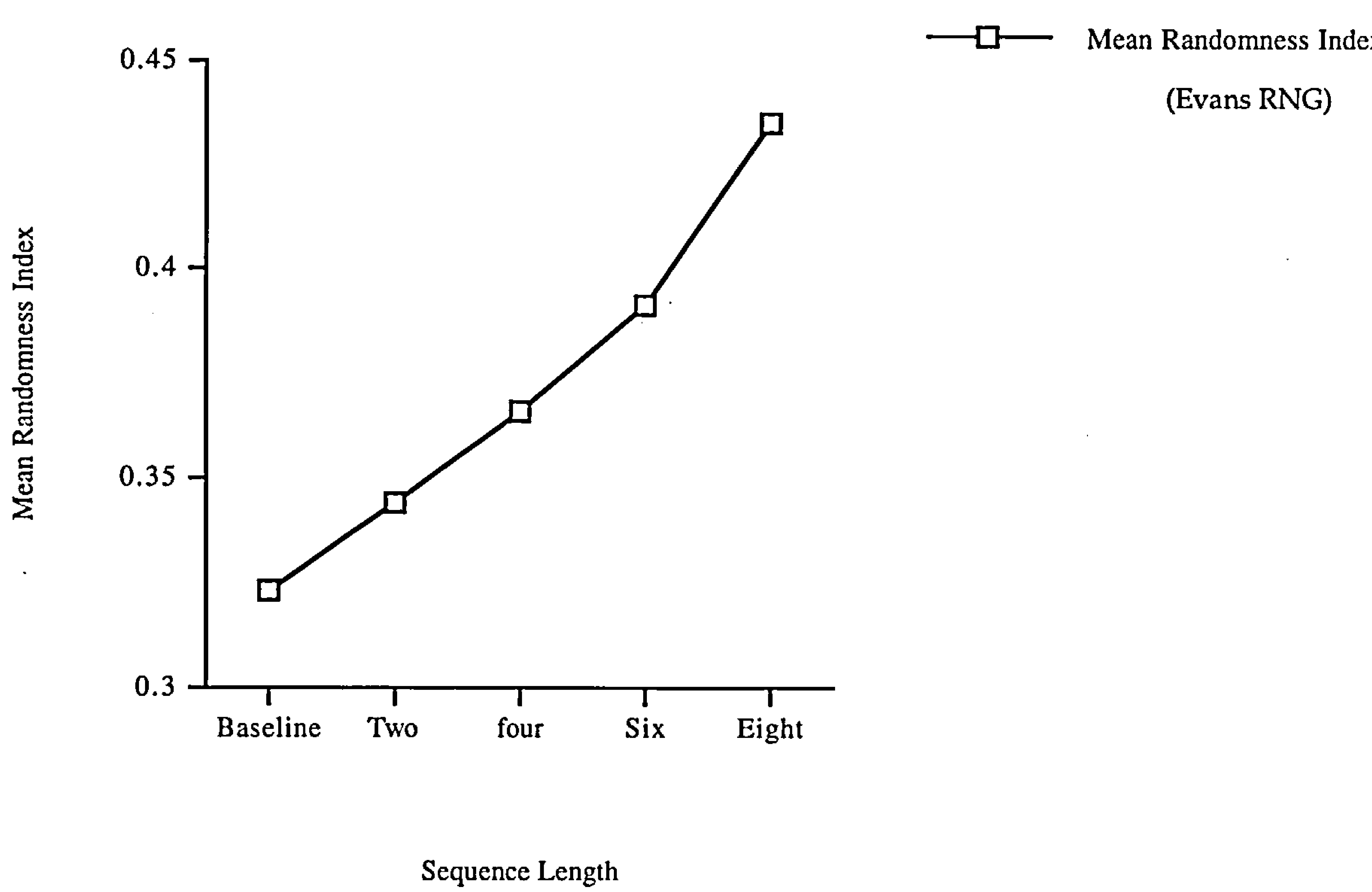

Figure 10.4 The effect of concurrent digit span task on Evans Index of Randomisation

Omission analysis - digit span task

Since there was a large number of omissions where participants failed to press the keys each time a beep sounded, an analysis of the percentage of omissions across the memory span task and autobiographical memory trials was computed. It is possible that the variation in omissions would offer a further indicator of information load. The number of occasions which participants failed to press a key in response to a tone were calculated as a % omission across all digit span trials for all participants.

The means and standard deviations of the % omission scores which occurred when participants performed the digit span task are shown in Table 10.6. A one way analysis of variance was computed across 5 digit span trials with % omission as the dependent variable. A significant effect of trial condition was shown $F(4,19) = 48.81$, $MSe = 17.50$, $p < .001$. Planned comparisons show that the % omission was significantly higher as the digit load increased with the highest number of omissions recorded in the 8 digit condition. There were significant differences in the % omission scores between baseline conditions and all digit span trials, ($p < .001$). Significant differences were also shown between when subjects were recalling sequences of 8 digits ($M = 18.95$) compared to 2, 4 and 6 digits, ($p < .01$). Similarly there was a significant difference between the 4 and 6 digit condition ($p < .05$).

Table 10.6

Means and S.D. of % omission scores in the digit span task

Baseline	Memory Span: Two	Four	Six	Eight
% omissions				
1.7(2.9)	10.39(7.1)	12.65(7.5)	15.80(6.8)	18.95(7.5)

Discussion.

The aim of this experiment was to further investigate a modified non verbal version of Baddeley's (1996) random generation task. To ensure that this version of the traditional random generation task is a sensitive measure of working memory capacity, the task should be sensitive to variation in processing load. An immediate memory span task was used to assess the sensitivity of the keyboard task. The results would suggest that random keypressing does reflect the operation of a limited capacity general working memory system. The greater the length of a concurrent digit sequence the poorer the performance on the random keypressing task.

The findings replicate those found in study 6 (a) but demonstrate further significant differences in the degree of randomness between the different digit conditions (2,4,6,8). The pattern of omission scores also suggests that the task is sensitive to variation in processing load with a significantly higher number of omissions occurring when participants were recalling sequences of 8 digits. Thus the keypressing version of the traditional random generation task can be regarded as a sensitive measure of variation in task processing demands. The results of interference on the digit span task when this task is combined with random keypressing reflects a graded effect (see Figure 10.4) such that the greater the length of the concurrent digit sequence, the poorer the performance on random generation. While both tasks are impaired when performance is combined, the effect of memory on random generation is directly related to load. The greater the length of the digit span, the greater the decrement in random generation. The effect of random generation on the immediate digit span task is constrained by ceiling effects particularly for sequence lengths 2 and 4. These ceiling effects mask any effect of trial condition at these lengths.

A question raised by this experiment was whether a visuo-motor keypressing task would be sensitive to the demands of concurrent performance in the different modality and domain of verbal memory. Daneman & Tardiff (1987) suggest that working memory is domain specific and that there are separate independent working memory resources for language and non language based information processing. In contrast to Baddeley's (1986) working memory model, a domain specific view of working memory rejects the notion of a central executive system and suggests that the different memory resources postulated are independent and self sufficient. Based on this premise one would not expect a perceptual motor response such as that involved in a key pressing task to be sensitive to a verbal task such as auditory digit span. The results of this experiment indicates that the two tasks interact strongly hence lending some support to the view that both are dependent on a general capacity central executive system.

There are a different models of working memory and each have implications for the role of the central executive function. The co-ordination function involved in the co-ordination of multiple tasks has been associated with the executive controlling component of a working memory system, thought to offer on line processing and temporary storage of information by means of a number of specialised functions (Baddeley, 1986). Within this model, there are separate specialised resources for visual spatial tasks and verbal, termed the visual spatial sketch pad and the phonological loop. Both of the latter structures are compatible with the proposal of Daneman & Tardiff (1987). However according to Baddeley's model the activities of these specialised resources is monitored by a central executive unit which is a limited capacity general purpose system.

A contrasting approach characterises cognitive resources as comprising a single yet flexible facility of limited capacity (Broadbent 1958, Just & Carpenter 1992) which can accomplish both processing and temporary storage. Support for this characterisation of a working memory system has been particularly prominent in the area of language processing. The working memory span task (Daneman & Carpenter 1980, 1983) which measures processing and storage functions suggests that participants with high spans appear to have greater comprehension capacity than do participants with low spans. A non specific processing plus storage characteristic of a working memory system suggests that dual task performance is made possible by time sharing the tasks and that performance of each task is unimpaired as long as the resources required to do the concurrent tasks does not exceed the total resources available. Whether working memory can be regarded as a single flexible cognitive resource or whether it comprises a number of different components each of which serves a different function (Baddeley 1986) has been the subject of much debate.

Cantor and Engle (1993), Engle et al (1992), Engle Nations & Cantor (1990), and Shute (1991) demonstrated that quantitative verbal, and spatial working memory tasks reflected a single cognitive factor and that this factor was a better predictor of learning than processing speed, general knowledge, or technical skill. There is also evidence for a common capacity that underlies auditory and visual working memory spans (Daneman & Carpenter 1980) and for those that require problem solving, reasoning or reading (Kyllonen & Christal 1990; Salthouse , Mitchell, Skovronek & Babcock 1989; Turner & Engle 1989). According to general capacity model these results indicate that working memory is a single unitary resource. This evidence is entirely consistent with Baddeley's (1986, 1996) assumption that random generation reflects the limited capacity of a general purpose executive system. The interaction between the keyboard generation task and an immediate verbal memory span is furthermore consistent with the notion of a general limited capacity central executive system which is not modality specific.

Overall, the results of this experiment suggests that random keyboard generation is a useful index of central executive function and also provides some limited support for the notion that working memory is a single unitary source which is non modality specific. The next experiment combines the random keyboard generation task with an autobiographical memory task to explore the role of the central executive in the recall of specific and general autobiographical memories.

Chapter 11

The Specificity of Autobiographical Memory and Central Executive Capacity.

Experiment 7 (a)

Chapter 9 suggested that autobiographical memories are constructed and maintained by the central executive component of working memory (Baddeley 1986; Norman & Shallice 1980; Williams 1992; and Conway 1992, 1993). The following experiment uses a modified keyboard version of the random generation task as a secondary task to identify central executive involvement in the retrieval of autobiographical memories. This version of the traditional random generation task has been shown in the previous two studies to be sensitive to working memory capacity when combined with an immediate memory digit span task.

Evidence reviewed in Chapter 9 also suggested that the process of generating random keypresses involves the setting up of a retrieval plan followed by close monitoring of output to detect stereotyped responses. It was proposed that retrieval of personal event memories involves a similar process in that a recursive search cycle is initiated and the retrieved memory trace must be monitored and examined to ensure it satisfies the experimental constraints of specificity. Hence both processes will compete for common attentional resources so that any decrement in randomness is taken to reflect the amount of effort devoted to the retrieval processes. The strategic retrieval of autobiographical memories as reviewed in Chapter 2 and 3 suggests that this process is a staged process involving intermediate descriptions and that failure to generate specific autobiographical memories may result in some circumstances from reduced working memory capacity. The consequence of such truncated or aborted searches is a general memory, because the retrieval of specific autobiographical memories is a more effortful process.

Why should the retrieval of specific autobiographical memories be more effortful? It is generally assumed that autobiographical knowledge is hierarchically organized with extended time events or lifetime periods as the first level, providing indices to more general events which represent more detailed knowledge. These events in turn index more event specific knowledge, or specific memories which form the deepest level in this hierarchy. A number of independent studies support the hierarchical model of autobiographical memory (Linton 1986; Barsalou 1988; Conway & Bekerian 1987 and Conway 1992,1993). Retrieval within such a structural model operates by a process of generative retrieval, based directly on Williams & Hollan's (1981) cyclical model of autobiographical memory retrieval.

This model assumes that there are three distinct but interdependent phases in the construction of an autobiographical memory. The first phase is to 'find a context' or memory description which involves elaboration of the memory cue, and this context is used to search memory. The second phase of a generative retrieval process involves a search of long term memory, and the final phase the output of the access phase is evaluated in terms of task demands. The aim of the evaluation phase, which is monitored by central executive resources is to determine whether the retrieval process can be terminated and a response executed or whether it is necessary to initiate another search cycle. It is the assumption that retrieving specific autobiographical memories involves more elaborations of the retrieval cycle that leads to the prediction that strategic access to specific autobiographical memories is more inherently effortful than the retrieval of general memories.

There have been few previous investigations into the generation of general memories especially using the cue word paradigm. General memories have been classified as 'errors' by Williams & Dritschel (1992) in tasks where participants are explicitly asked to retrieve specific memories in response to cue words. Barsalou (1988) suggests that because generic concepts are often better established in memory than exemplars, such summarisations may be increasingly more accessible than a particular event memory. Thus if a second repeated event does not cue exemplars from the first event, it may cue the more accessible general memory which in turn guides processing of the second event. As increasing numbers of instances of events are encoded, general event memory becomes more established, and as a result the specific events which comprise such instances should become increasingly difficult to access.

According to Barsalou (1988) increasing the number of instances or specific events should increase the gap between the accessibility of general memories and the accessibility of those specific instances. This generic memory for events was explored by Watkins & Kerkar (1985) and their findings are consistent with Barsalou's hypothesis by demonstrating that recall of repeated items can not fully be accounted for in terms of their individual presentation but results instead from recall of presented pairs in a general or summarised fashion. Hence, recall of general memories should involve less effort than the retrieval of specific event memories. Although this hypothesis has been assumed, no experiment to date has examined this prediction directly and compared conditions in which participants are instructed to retrieve either a specific or a general memory.

The retrieval of general memories and specific memories in response to cue words is explored to compare the effortfulness involved in both retrieval processes. The role of central executive and the retrieval of autobiographical memories is investigated using the random keypressing task as a secondary task. The autobiographical memory task is the same paradigm used in experiments 1 to 3 and involves presenting cues which are both high and low in imageability to participants and requesting them to generate specific memories in response to those cues.

In this experiment the additional manipulation of instruction involves requesting participants to retrieve general memories in response to one set of high and low imageable cues, and specific memories in response to a different (matched) set of cues. It is predicted that the randomness of the keypressing task will be significantly less in trials where participants are instructed to retrieve specific memories particularly in response to low imageable cues. On the other hand where participants are requested to retrieve general memories the randomness of the keypressing task should be greater. No prediction is made with regard to the differences in the number of general memories retrieved to high versus low imageable cues following instructions to be generic as this is the first time that this instruction manipulation has been tested.

Procedure

Subjects. There were twenty six participants in this experiment; 19 females and 7 males ranging in age from 18 to 45 years. They were recruited from the undergraduate subject pool at U.W.B. where participation in experiments is a part requirement for course credits.

Design The autobiographical memory task was a within subjects design where cue imageability (high and low) and memory instructions (specific and general) were both within subject factors.

Materials. A specially constructed keyboard was used to run the random keypressing task as in the previous experiment. This keyboard measured 57 cm x 70 cm and contained two groups of five keys. The keys were 2 cm wide and 1.3 cms apart. The keyboard was connected to a Mackintosh Classic 11 which recorded each keypress. The ten keys were numbered from 0 to 9 consecutively.

Autobiographical Memory Task.
In the autobiographical memory task, participants were required to recall events that had happened to them, in response to high and low imageable cues. The time period from which events could be recalled was not specified and participants were told that the event could be important or trivial. Two different instructions were given in a within subjects design. In one autobiographical memory trial (specific) it was emphasised that the events from the past should be of specific events (events that lasted less than one day). The second autobiographical memory trial (general) instructed

participants to recall general activities or happenings in response to cues. A total of three cues was used for each memory trial when the task was performed alone and combined with the keypressing task and the presentation of cues for each trial condition was counterbalanced. The cues used in the 'Specific' autobiographical memory trials and those used in the 'General' memory trials are shown in Table 11.1.

Table 11.1

Instructions			
Specific		General	
Imageability			
High	Low	High	Low
Butterfly	Wisdom	Robbery	Mood
Mountain	Attitude	Sea	Legislation
Cloud	Moral	Ladder	Hearing
House	Boredom	Grass	Greed
Painting	Explanation	Library	Thought
Fire	Obedience	Letter	Effort

Autobiographical memory tasks.

Specific Autobiographical Memories

Participants were asked to retrieve specific memories of past events in response to 3 high imageable words and in response to 3 low imageable cue words. The instructions given were;

> " I am interested in your memory for events that have happened in your life. In response to a cue word which I shall call to you, I would like you to respond with a memory. The memory must be a specific memory of an event which has happened. The event could have happened in the recent past or a long time ago. For example, if I say the word 'party', you could respond with "I went to a very enjoyable party last Saturday night with friends".

All participants were given practice trials to ensure familiarity with the task.

General Autobiographical Memories.

Also they were requested to recall general memories of events in response to 3 high and low imageable cue words. The actual instructions given in this condition were;

> " I am interested in your memory for events that have happened in your life. In response to a cue word which I shall call to you, I would like you to respond with a memory. The memory could be a memory of the time spend in college studying for A levels or times you spent

going to the pub with friends. These events which you recall can have happened in the recent past or a long time ago.

All participants were given practice trials to ensure familiarity with the task. Both autobiographical memory tasks were performed singly and concurrently with the secondary key pressing task. To ensure that all participants were actively retrieving information from autobiographical memory while performing the concurrent key pressing task, they were encouraged to recall more information about the events they had retrieved until approximately 30 seconds had elapsed and the following cue was given.

Results.

The results of the autobiographical memory task are reported in two separate sections. The first section discusses specific autobiographical memories while the second section addresses general memories

Specificity of Autobiographical Memories.

The means and standard deviations of the specificity of autobiographical memories retrieved when the autobiographical memory task was performed as a single task and concurrently with the keypressing task are shown in Table 11.2. A 2 (Imageability; high and low) X 2 (trial; single and combined) x 2 (instructions; specific or general) ANOVA was computed where memory specificity was the dependent variable. All the factors were within subject factors. Specificity scores were computed as in experiments 1, 2, and 3 where a specific response scored 3 points, an intermediate response scored 2 points, a general response 1 point and omissions scored 0.

Table 11.2

Means and standard deviations of memory specificity across all trials.

	Instructions			
	Specific		General	
Cue Imageability	High	Low	High	Low
Trial condition				
Single	7.6(1.3)	6.5(1.4)	5.0(1.4)	4.0(1.2)
Combined	8.0(0.9)	5.0(2.0)	5.9(1.3)	3.9(1.2)

The results showed a main effect of instructions $F(1,25) = 175.55$, $MSe = 1.27$ $p < .001$, and of imageability, $F(1,25) = 132.33$, $MSe = 1.25$, $p < .001$, with the predicted higher memory specificity responses being given when the instructions demanded them and in response to cues high in imageability. There was no overall significant difference in the specificity of autobiographical memories when the task was performed singly or combined with the keypressing task, with no main effect of trial condition $F(1,25) = 0.01$, $MSe = 1.96, p > .05$. However a significant interaction was shown between trial condition and memory instruction $F(1,25) = 7.45$, $MSe = 1.48$, $p < .05$. The means table of this interaction is shown in Table 11.3.

Table 11.3

Means of Memory Specificity in Conditions x Instructions Effect

		Trial conditions	
	N	Single	Combined
Instructions			
Specific	52	7.01(1.5)	6.55(2.1)
General	52	4.53(1.4)	4.94(1.6)

The difference in the specificity of memories retrieved following specific and general instructions is greater in single task conditions than in combined trials. A significant interaction was also demonstrated between trial condition and imageability $F(1,25) = 10.06$, $MSe = 2.61$, $p<.01$. The means table of this interaction is shown in Table 11.4.

Table 11.4

Means of Memory Specificity in Trial conditions x Imageability

		Trial conditions	
	N	Single	Combined
Imageability			
High	52	6.34(1.9)	7.00(1.5)
Low	52	5.26(1.8)	4.50(1.7)

To further examine the effects of imageability and trial condition and the above interaction, a separate 2 x 2 ANOVA was performed for specific instructions alone since this condition most closely follows previous autobiographical memory experiments I and 2. Imageability (high and low) and trial condition (single and combined) were treated as within subject variables. A main effect of imageability was shown $F(1,25) = 58.98$, $MSe = 1.86$, $p<.001$. There was no main effect of trial condition (single or combined task) ($F(1,25) = 3.92$, $MSe = 1.80$, $p>.05$) on the specificity of autobiographical memories retrieved. However a significant interaction was shown between cue imageability and trial condition $F(1,25) = 8.50$, $MSe = 2.50$, $p<.01$. The means table of this interaction is shown in Table 11.5.

Table 11.5

Means of Memory Specificity in Trial Conditions x Imageability

		Trial conditions	
	N	Single	Combined
Imageability			
High	26	7.65(1.3)	8.04(0.9)
Low	26	6.50(1.4)	5.01 (1.2)

Figure 11.1 illustrates this interaction and shows a greater number of specific memories being retrieved to low imageable cues in single task conditions compared to that in combined trials. In response to high imageable cues however participants retrieved more specific memories in combined trials compared to single task conditions.

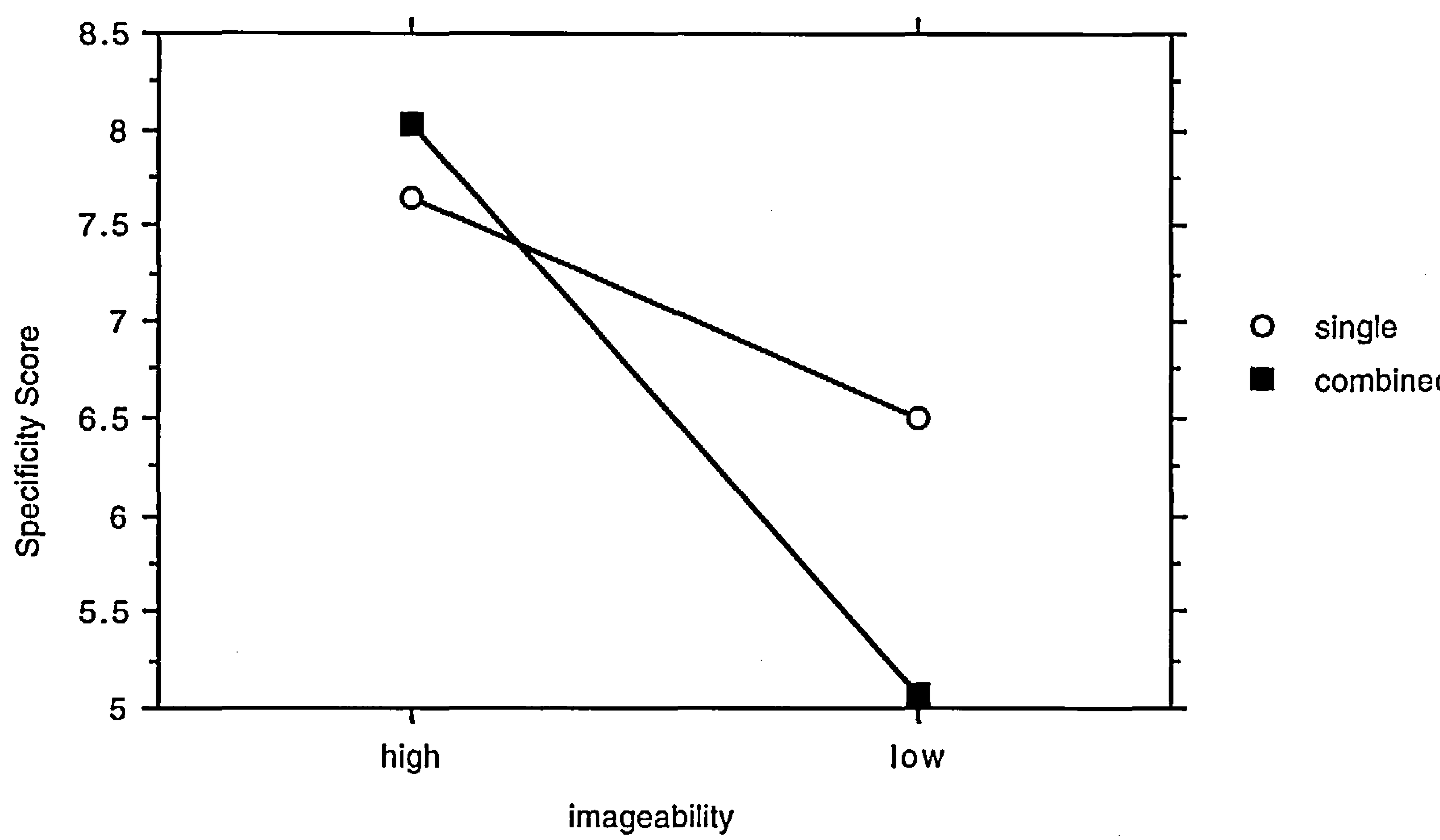

Figure 11.1. Memory Specificity in single and combined task conditions.

Planned comparisons show a significant difference between the specificity of memories retrieved in response to low imageable cues in single ($M = 6.5$) and dual task conditions, ($M = 5.0$, $p<.01$). The difference in memory specificity between memories retrieved to high imageable cues both in single trials and combined trials was not significant, ($p>.05$). Significant differences were also shown in the specificity of memories retrieved between high and low imageable cues in single trials ($p<.01$) and also in combined trials ($p<.001$) The specificity of memories retrieved was greater for high imageable cues compared to low imageable cues in both task conditions.

In summary, the memory results suggest that more specific memories are retrieved in response to high imageable cues following instructions to be specific. In addition a prediction that trials where participants were instructed to retrieve specific memories in response to low imageable cues would be most effortful was demonstrated by a significant difference in the specificity of memories retrieved when the task was performed as a single task compared to the dual task where the keypressing task was performed concurrently.

General Memories.

The means and standard deviations of the number of general memories retrieved by participants when the autobiographical memory task was performed as a single task and combined with the keypressing task are shown in Tables 11.6 and 11.7. A 2 x2 x 2 ANOVA similar to that performed for autobiographical memory specificity was computed. The three within subject factors were type of memory instruction (specific and general), imageability (high and low) and trial condition (single or combined). Two main effects were shown; memory instructions, $F(1,25) = 88.25$, $MSe = 0.94$, $p<.001$ and cue imageability ($F(1,25) = 64.85$, $MSe = 0.52$, $p<.01$) due to significantly more general memories being retrieved following instructions to be generic and also significantly more general memories retrieved in response to low imageable cues.

A significant interaction was demonstrated between instructions and imageability $F(1,25) = 33.44$, $Mse = 0.42$, $p<.001$. The means table of this interaction is shown in Table 11.6, which demonstrates that considerably fewer general memories were retrieved by participants in response to high imageable cues following specific instructions compared to the number of general memories retrieved to high imageable cues following general instructions.

Table 11.6

Means and standard deviations of the number of general memories retrieved in the effect of instructions x imageability

		Instructions	
	N	Specific	General
Imageability			
High	52	0.7(0.7)	2.5(0.8)
Low	52	2.0(0.9)	2.8(0.50

A significant interaction was also shown between trial condition and instructions and imageability $F(1,25) = 6.04$, $MSe = 0.25$, $p < .05$. The means table of this interaction is shown in Table 11.7.

Table 11.7

Means and standard deviations of the number of general memories retrieved across all memory trials.

	Instructions			
	Specific		General	
Imageability	High	Low	High	Low
Trial condition				
Single	0.6(0.7)	2.0(0.9)	2.7(0.5)	2.8(0.5)
Combined	0.7(0.7)	2.0(0.9)	2.2(0.9)	2.8(0.5)

Less general memories were retrieved to high imageable cues following general instructions in combined trials compared to that in single trials. To further examine the effects of these interactions a 2 (Imageability; high and low) x 2 (trial; single and combined) ANOVA was computed with the number of general memories retrieved as the dependent variable. A main effect of trial condition was shown, $F(1,25) = 7.92$, $MSe = 0.20$, $p < .01$, due to more general memories retrieved in the single trial conditions. A main effect of imageability was also demonstrated, $F(1,25) = 9.68$, $Mse = 0.22$, $p < .01$. More general memories were constructed in response to low imageable cues.

There was a marginal significant interaction between trial condition and imageability F (1,25) = 4.45, Mse = 0.36,p = 04. Planned comparisons showed a significant difference in the number of general memories retrieved to high imageable cues in single trials (M = 2.7) and combined trials (M = 2.2), p <.05.

Random generation task and the recall of autobiographical memories.

Evans (RNG) analyses.

The means and standard deviations of Evans RNG measures across all autobiographical memory trials and baseline trials are shown in Table 11.8. Evans index of randomisation (RNG) was treated as the dependent variable in a one way analysis of variance incorporating baseline measures of randomness and four autobiographical memory trials. It showed a significant effect of trial condition (F, (4,21) = 7.41, MSe = 0.01, p <.001). Planned comparisons showed a significant difference in randomness between the baseline condition and all four autobiographical memory trials (p <.01). Within the four autobiographical memory trials no significant differences in randomness were found (p>.05).

A 2 (autobiographical memory instructions; specific or general) x 2 (Cue; high and low imageability) factorial ANOVA showed no significant main effects or interactions (F <1 for all effects).

Table 11.8

Means and standard deviations of Evans (RNG) index across all trials.

	Instructions			
	Specific		General	
	Cue Imageability			
Baseline	High	Low	High	Low
0.318(0.1)	0.379(0.1)	0.395(0.1)	0.396(0.1)	0.386(0.1)

Omission Analysis

The means and standard deviations of the number of omissions where participants failed to press a key in response to the tone are shown in Table 11.9. Three participants with high omission scores in baseline trials were omitted from this analysis. A one way ANOVA incorporating baseline measures and the four memory trials showed a significant effect of trial condition $F(4,22) = 12.97$, $MSe = 31.22$, $p < .001$. Planned comparisons showed significant differences between the % of omission scores in baseline trials and all autobiographical memory trials ($p < .001$). Also significantly fewer omissions occurred in trials where participants were instructed to recall general memories in response to high imageable cues compared to trials where participants were given specific instructions and high and low imageable cues ($p<.05$).

A 2 (memory instruction; specific or general) x 2 (imageability; high and low) ANOVA was also computed with % omissions as the dependent variable. There was no significant effect of instructions or cue imageability ($p > .05$).

Omissions- autobiographical memory task.

The number of omissions where participants failed to retrieve a memory in response to a cue word across all memory trials were examined. There were no omissions when participants were instructed to retrieve either specific or general memories in response to high imageable cues. A total of 9 omissions occurred following specific instructions with low imageable cues and a total of 3 omissions in trials where participants were instructed to retrieve general memories in response to low imageable cues. These differences were analysed using Wilcoxon signed rank test and found to be non significant ($z = 1.66$, $p > .05$). These totals are presented as % omissions in Table 11.9.

Table 11.9

Means and standard deviations of % omissions for both tasks..

		Instructions			
		Specific		General	
		Cue Imageability			
	Baseline	High	Low	High	Low
RKT	1.3(2.1)	11.5(9.4)	11.0(8.8)	7.3(6.9)	9.7(9.8)
ABM.	n.a.	0	1.33%	0	0.6%

Key: ABM refers to the autobiographical memory task, RKT refers to the random keypressing task.

Discussion

The aim of this experiment was to examine the role of central executive resources in the retrieval of autobiographical memories using a dual task paradigm. A modified version of the traditional random generation task was used as a secondary task, whereby participants were requested to press keys randomly on a specially constructed keyboard in response to a tone emitted by the computer.

Analysis of the randomness of keypressing across baseline measures and where participants were retrieving both specific and general autobiographical memories to high and low imageable cue words showed no significant difference in the degree of randomness between all four memory trials. However a significant difference was found in the randomness of keypresses between baseline measures and all four memory trials with greater randomness found in baseline measures where the secondary keypressing task was performed as a single task. Also significantly less omissions where participants failed to press a key in response to a tone were made in baseline trials compared to autobiographical memory trials.

Within the autobiographical memory trials there were significantly less omissions made when participants were instructed to retrieve general memories in response to high imageable cues compared to trials giving instructions to retrieve specific memories in response to high and low imageable cues. This is consistent with the prediction that participants would find the task of retrieving general memories less effortful. There was no significant difference in the number of keypressing omissions made between trials following instructions to retrieve general memories in response to high imageable cues versus low imageable cues.

The dual task paradigm allows us to examine the effect of generating random keypresses on the ability of participants to retrieve specific and general autobiographical memories. Concurrent random generation had a significant effect on the recall of specific autobiographical memories only when participants were attempting to retrieve specific events in response to low imageable cues. This effect is consistent with findings from Baddeley (1996) who showed that although keyboard pressing did not disrupt a verbal fluency task or a digit generation task, there was significant impairment on a verbal reasoning task. The finding that random keypressing did disrupt specificity of memory retrieval in the condition predicted to be most effortful (with low imageable cues) is consistent with a possible 'trade off' between both tasks.

Trials where participants were instructed to retrieve specific memories in response to low imageable cues is the condition in which a decrement in randomness was most clearly predicted (as a result of an effortful memory search). Yet instead, performance on the random keypressing task was maintained while participants retrieved fewer specific autobiographical memories. Both the smaller number of omissions on the keypressing task in the easiest condition (instructions to retrieve general memories with high imageable cues) and the impaired memory performance in the most difficult condition (instructions to retrieve specific memories with low imageable cues) suggests a trade off between memory performance on the autobiographical memory task and the random generation task. Such a trade off is consistent with the hypothesis that the effort involved in the retrieval of specific autobiographical memories produces truncated searches. However the failure of the secondary task to reflect differences in randomness when participants were instructed to retrieve either specific or general memories is not consistent with this hypothesis.

Why did the random keypressing task fail to reflect the predicted differences in effortfulness of retrieving specific versus general memories? Firstly, it is possible that the randomness task was insensitive to the differences in the processing demands between retrieving a specific and a general memory. However the observed differences in the % omission scores following specific and general instructions for high imageable cues (with significantly less omissions where participants were asked for general memories in response to high imageable cues) would suggest that the randomness task was sufficiently sensitive. Also the results of the digit span task in the two previous experiments would suggest that the random keypressing task was sensitive to processing demands in working memory.

Nevertheless, it is possible that Evans Index of randomness (RNG) was less sensitive to variations in randomness within the autobiographical memory trials. Therefore, the second part of this study includes another measure of randomness in addition to the Evans Index. This measure is a triplet measure and has been shown in Experiment 5 to be a sensitive to changes in randomness across short sequences.

A second possibility is that too few cues were used in the autobiographical memory task trials and that participants were too easily able to time share between both tasks, thus maintaining performance on the keypressing task in all memory trials. To reduce the possibility of time sharing, it is necessary to repeat this experiment using more cues in all trial conditions thus ensuring that participants are actively retrieving while performing the keypressing task. Eliciting more memory responses in each trial condition would also allow a detailed analysis of the different types of memories retrieved by participants. Specifically if participants are truncating their search this should show up in a qualitative analysis of responses. A hierarchical model of autobiographical memory assumes that memories are accessed via structures whereby general events index specific events. Personal semantic memories or facts (e.g. names of schools or teachers) would lie at the head of such a hierarchy and if participants are unable to access a specific memory they can truncate their search and (depending on whether the instructions are specific or general) opt for a general memory rather than a specific memory or for a semantic memory instead of a general memory. A qualitative analysis of all memory responses should reflect such a hierarchical organization and help to identify those retrieval strategies adopted which enabled them to maintain performance on the keypressing task.

Thus, the following experiment further examines in more detail the effect of the retrieval of specific and general autobiographical memories on a random keypressing task following instructions to be either specific or general. Since the failure to demonstrate a significant difference in the randomness of the keypressing task following instructions to be specific versus general in this study is the most pressing concern, the second part of this study focuses just on those experimental conditions where participants are instructed to retrieve either specific or general memories while performing the keypressing task concurrently.

The Specificity of Autobiographical Memory and Central Executive Capacity.

Experiment 7 (b)

The second part of this study aims to further explore the role of the central executive in the retrieval of autobiographical memories with the following modifications. Firstly more cues (10 in total) are used in each autobiographical memory trial and secondly two measures of randomness are used and these include Evans (RNG) index and a triplet measure. Finally participants do not perform the autobiographical memory task as a single task.

Procedure

Subjects. There were 37 participants in this experiment, 25 females and 12 males with an average age of 28 years (18 - 45 years) All participants were undergraduate students in the U.W.B. and were recruited from the undergraduate subject panel as part fulfilment of course credits.

Design. A 2 (imageability - high or low) x 2 (memory instructions - specific or general) within subjects design was used.

Materials. A specially constructed keyboard similar to that in the previous studies was used to run the random keypressing task.

Measures. The standard autobiographical memory task was used in this experiment, using a within subjects design. The cues used in each trial are shown in Table 11.10

Table 11.10

Cues used in the autobiographical memory task.

Instructions			
Specific		General	
Imageability			
High	Low	High	Low
Factory	Knowledge	Butterfly	Obedience
Teacher	Upkeep	Mountain	Explanation
Baby	Worth	Cloud	Boredom
Nun	Malice	House	Hearing
Poetry	Ability	Painting	Legislation
Robbery	Mood	Fire	Thought
Sea	Permission	Grass	Greed
Bouquet	Law	Library	Moral
Coffee	Effort	Letter	Attitude
Rose	Duty	Lake	Wisdom

Measures of Randomness

1. Triplets (T). The statistic TRIPLETS is the number of triplets that appear only once in a sequence. The higher the triplets the less repetition there is in a sequence. This measure has been investigated in Chapter 9.

2. Evans (RNG). The (RNG) index was adapted from Tulving's (1962) subjective organization index and is similar to that used in the last three studies (6 (a), 6 (b) and 7(a).

Method.

The same procedure was followed as in experiment 7 (a). All participants were given practice trials to ensure familiarity with the keypressing task. In the autobiographical memory task, a total of 4 trials per participant were run, (specific instructions with high and low imageable cues and generic instructions using high and low imageable cues). There were 10 cue words in each trial (see Table 11.9). In the concurrent task subjects were requested to press the keys as randomly as possible whilst retrieving memories in response to the cue words called aloud by the examiner. The interval between memory trials was 13 seconds, and participants were given 10 seconds to respond to each cue. If they failed to respond within that time the following cue was called. The keypressing trials lasted for 130 seconds during which subjects were presented with 10 cue words.

Results

The results of the autobiographical memory task are reported in two sections, the first section reports the specificity of autobiographical memories retrieved while the second section reports the number of general memories retrieved.

Specificity of Autobiographical Memories

The means and standard deviations of memory specificity across all four trials are shown in Table 11.11. Memory specificity was calculated as in the previous experiment. A 2 (instructions; specific or general) x 2 (imageability; high or low) ANOVA was computed on the specificity of autobiographical memories retrieved by participants following specific instructions. A main effect of type of instruction was shown $F(1,36) = 176.00$, $MSe = 12.16$, $p < .001$, and a main effect of imageability $F(1,36) = 77.14$, $MSe = 9.59$, $p<.001$. More specific memories were retrieved in response to high imageable cues and following specific instructions. A significant interaction was also found between instructions and imageability $F(1,36) = 19.39$, $MSe = 6.35$, $p <.001$. The means table depicting this interaction is shown in Table 11.11.

Table 11.11

Means and standard deviations of memory specificity

	Instructions			
	Specific		General	
	Cue Imageability			
	High	Low	High	Low
Specificity	26.29(3.0)	20.0(5.1)	16.86(2.0)	14.21(3.3)

This interaction is shown in Figure 11.2 and is due to a greater difference in the specificity of memories retrieved between high and low imageable cues following specific instructions (Difference = 6.29) compared to a smaller difference to the specificity of memories retrieved between high and low imageable cues following general instructions (Difference = 2.65). Thus, the effect of imageability is greater when participants are instructed to retrieve specific memories compared to when they are instructed to retrieve general memories.

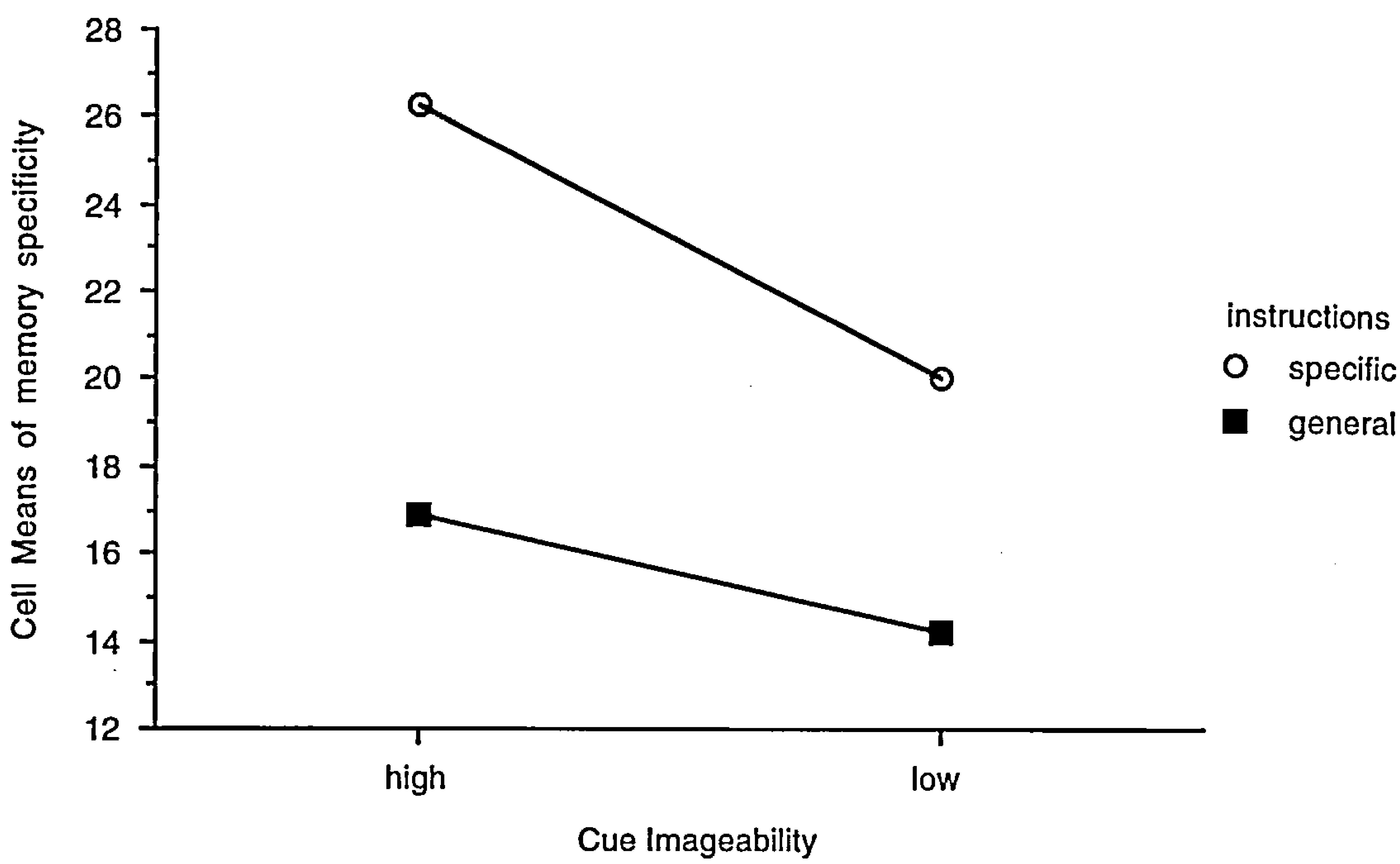

Figure 11.2. Memory specificity to high and low imageable cues following specific and general instructions

General Memories

The means and standard deviations of the number of general memories retrieved are shown in Table 11.12. A 2 (instructions; specific or general) x 2 (imageability; high or low) ANOVA was computed in this experiment across the total number of general memories retrieved. A main effect of instruction was found F(1,25) = 260.98, MSe = 3.89, p <.001 and also a main effect of imageability F (1,25) = 11.66, MSe = 3.34, p <.01. Participants retrieved more general memories when instructed to be generic and in response to low imageable cues compared to high imageable cues. A significant interaction was found between type of instruction and imageability F (1,36) = 7.65, MSe = 1.86, p<.01. Figure 11.3 demonstrates this interaction and the means table is shown in Table 11.12

Table 11.12

Means and standard deviations of general memory retrieval

	Instructions			
	Specific		General	
	Cue Imageability			
	High	Low	High	Low
General Memories	2.27(1.45)	3.92(2.3)	8.13(1.4)	8.54(1.6)

This interaction is due to a greater difference between the number of general memories retrieved in response to either high or low imageable cues following specific instructions (Difference = 1.65) compared to the far smaller difference in those trials where participants were instructed to retrieve general memories to both high and low imageable cues (Difference = 0.41).

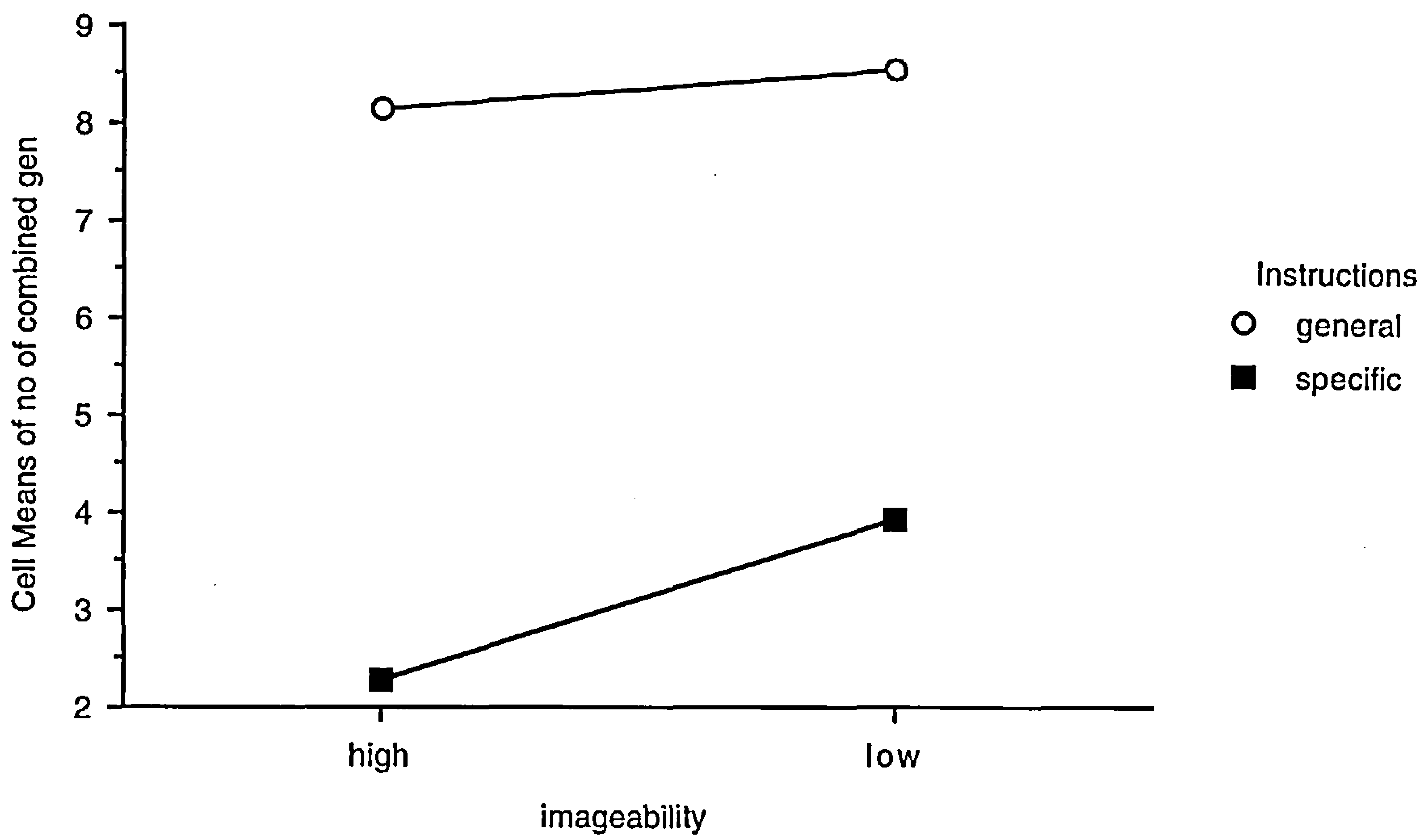

Figure 11.3 Retrieval of general memories to high and low imageable cues and following specific and general instructions

Sub-dividing non specific memories.

Table 11.13 shows the number of specific, and non specific autobiographical memories retrieved by participants. The number of omissions, and different types of general memories are also included. Those general memories retrieved by participants were sub divided into two main types. Williams & Dritschel (1992) when examining their data for non specific memories focused mainly on a type of general memory they termed 'categoric'. Categoric memories refer to a category of events containing a number of specific episodes, e.g. 'drinking in pubs' or 'mountain hikes with friends'. Extended memories refer to extended periods of time 'times I lived in Cambridge'. These memories are not distinguished in this study as it is assumed that both categoric and extended memories occupy similar locations on a structural hierarchy. A third type of response is identified as personal semantic memories; where participants responded with the name of a person or location or where a definition of the cue word was given.

Table 11.13

Pattern of retrieval in Autobiographical Memory Task

	Instructions			
	Specific		General	
	Cue Imageability			
Memories	High	Low	High	Low
Specific Memories[1]	7.35(1.9)	4.40(2.2)	1.59(1.3)	0.51(1.2)
Omissions	0.38(0.6)	1.75(1.8)	0.22(0.6)	0.84(1.2)
Non- specific Memories	2.27(1.8)	3.91(2.3)	8.13(1.4)	8.54(1.6)
Categoric/Extended	1.95(1.7)	2.97(1.8)	4.76(2.0)	3.10(2.1)
Semantic	0.32(0.7)	0.86(1.2)	3.38(1.8)	5.35(2.7)

[1] Instead of reporting a specificity score, the actual total number of specific memories retrieved by participants are reported in the above table to enable direct comparisons to be made with the other types of memories

Categoric/ Extended Memories

The means and standard deviations of the number of categoric memories retrieved are shown in Table 11.13. A 2 (instructions) x 2 (imageability) ANOVA was computed treating the number of categoric memories as a dependent variable. A significant effect of instructions was found $F(1,36) = 13.53$, $MSe = 5.93$, $p < .001$ and a significant interaction was found between instruction x imageability $F(1,36) = 30.75$, $MSe = 2.15$, $p < .001$. More categoric memories were retrieved in response to low imageable cues versus high imageable cues following specific instructions.

Planned comparisons showed that significant differences were shown in the number of categoric memories retrieved in response to high and low imageable cues following specific instruction ($p < .01$). Also significantly more categoric/extended memories were retrieved to high imageable cues following general instructions than those retrieved to low imageable cues.

Semantic Memories.

The means and standard deviations of the number of semantic memories retrieved by participants are shown in Table 11.13. The results of a similar 2 x 2 ANOVA show significant effect of both instruction $F(1,36) = 185.10$, $MSe = 2.84$ $p < .001$ and of imageability $F(1,36) = 28.12$, $MSe = 2.07$, $p < .001$. More semantic memories were retrieved in response to low imageable cues and when participants were instructed to be general. A significant interaction was found between type of instruction and imageability $F(1,36) = 12.82$, $MSe = 1.48$, $p < .01$. This interaction is due to the larger difference between the number of semantic memories retrieved in response to both high and low imageable cues following general instructions compared to the number of semantic memories retrieved to such cues following specific instructions

Planned comparisons show that following general instructions more semantic memories were retrieved in response to low imageable cues compared to the number of semantic memories retrieved in response to high imageable cues ($p<.001$). The differences between the other conditions in this autobiographical memory task all reached significance ($p <.001$).

Random Generation Measures: A series of one way ANOVAs on the 2 measures of randomness was performed followed by factorial ANOVAS, where cue imageability and type of autobiographical memory were treated as within subject variables. The means and standard deviations of both randomness measures across all autobiographical memory trials and baseline conditions are shown in the following Table 11.14.

Table 11.14

Measures of randomness for all memory trials and baseline

		Instructions			
		Specific		General	
		Cue Imageability			
Measure	Base	High	Low	High	Low
Evans	0.304(.04)	0.378(.07)	0.367(.06)	0.364(.06)	0.373(.07)
Triplets	78.3(8.7)	66.0(12.6)	68.6(11.6)	68.6(11.6)	66.61(12.6)

Key . Base refers to baseline trials where the random keypressing task was performed as a single task

Evans RNG. The results of this measure of randomness for baseline and autobiographical memory trials are shown in Figure 11.4 (Three participants with Rng values greater than 1 were excluded from this analysis). There was a significant difference between baseline measures and all memory trials $F(4,33) = 16.204$, $MSe = 0.01$, $p < .001$. Planned comparisons showed that the difference between baseline and cue memory trials all reached significance ($p<.01$) suggesting that the randomness of baseline measures was significantly greater when compared to that in the autobiographical memory trials. No significant differences in randomness were shown within the four autobiographical memory trials.

A 2 (Memory instruction; specific or general) x 2 (cue type; high imageable or low imageable) ANOVA with Evans RNG as the dependent variable was not significant for either effect ($F < 1$ in both cases.)

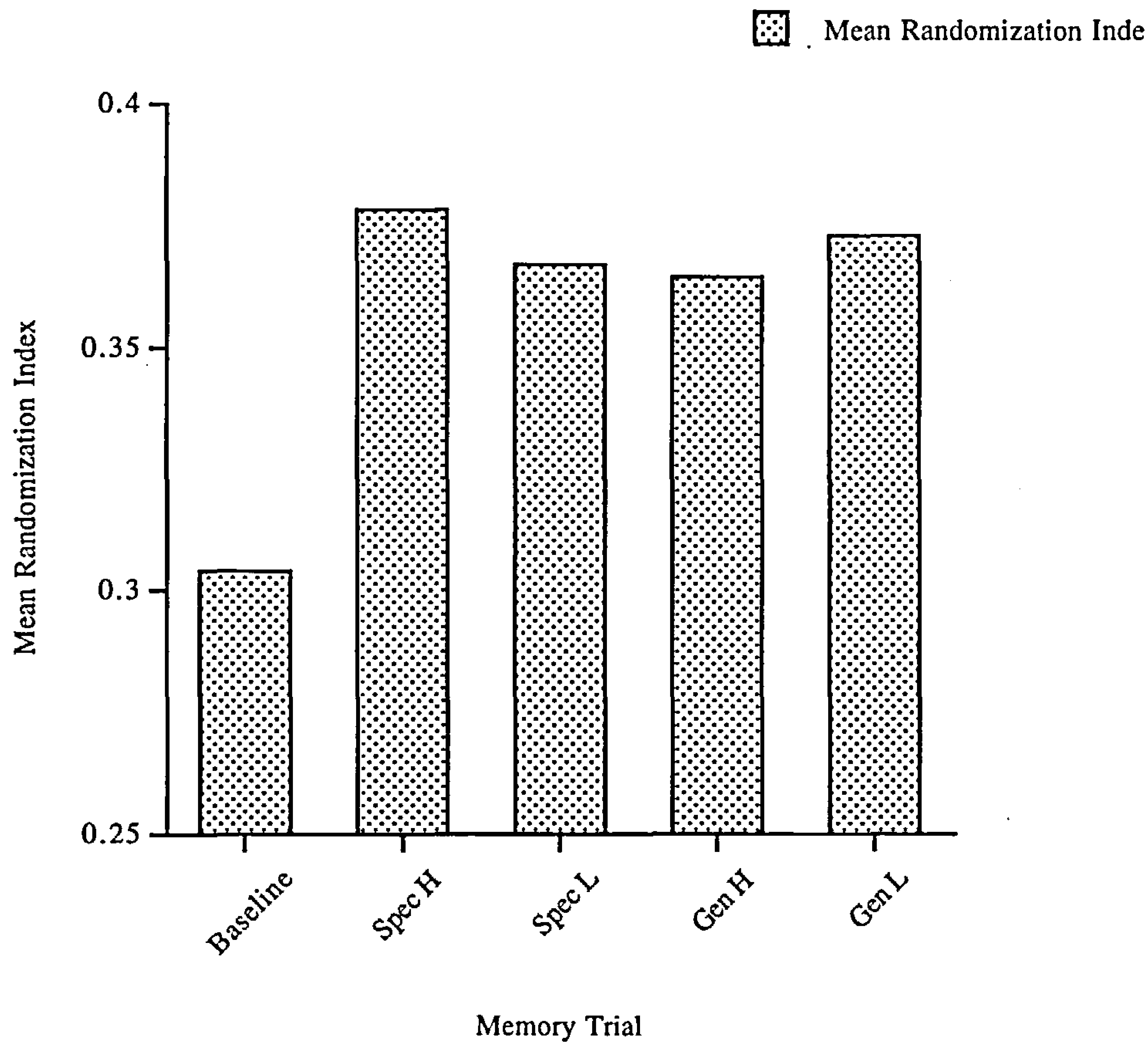

Figure 11.4 Rerieval of autobiographical memories and random generation.

Triplets: When randomness was assessed using a triplet measure, one way analysis of variance demonstrated a significant difference between baseline measures and memory trials ($F(4,33) = 10.94$, $MSe = 78.17$, $p < .001$) Planned comparisons between baseline and memory trials all reached significance, $p < .001$. No significant differences were shown between the four memory trials ($p > .05$). A 2 x 2 ANOVA with cue imageability and type of autobiographical memory as within subject variables was not significant for either effect ($F < 1$ in both cases)

Omission analysis: Random Generation Task

The means and standard deviations of the % keypressing omissions are shown in Table 11.15. A one way ANOVA was computed to examine the % of omissions when participants failed to press the keys in response to the tone. The number of omissions was calculated as a % omission score across all trials. (Outliers with high omission scores in memory and baseline trials were excluded from this analysis). The results show a significant difference between baseline and the four memory trials $F(4,31) = 42.88$, $p < .01$. Planned comparisons show that the difference between baseline measures and all memory trials were significant ($p < .01$). No significant differences were found between autobiographical memory trials on the % of omissions per trial. An additional 2 (instructions; specific or general) x 2 (imageability; high or low) ANOVA was computed for the memory trials alone. No significant main effects or interaction were shown ($p > .05$)

Autobiographical Memory Omissions.

The means and standard deviations of the number of omissions on the autobiographical memory task are also shown in Table 11.15. Instances where participants failed to respond to the cue word were classed as a memory omission and summed across all memory trials. A 2 (instructions -specific and general) x 2 (imageability - high and low) ANOVA where the dependent variable was the number of omissions on the autobiographical memory task showed a significant effect of imageability ($F(1,36) = 19.58$, $MSe = 1.88$, $p < .001$), and a significant effect of instruction ($F(1,36) = 19.27$, $MSe = 0.56$, $p < .001$). Overall there were more omissions to low imageable cues and following instructions to be specific. A significant interaction was also found between instruction x imageability $F(1,36) = 6.88$, $MSe = 0.77$, $p < .05$.

Planned comparisons reveal that participants made a significantly greater number of omissions to low imageable cues following specific instructions (5% omissions) compared to the other conditions ($p<.01$).

Table 11.15

Omission Scores (%) on the random generation task and the autobiographical memory task

		Instructions			
		Specific		General	
		Cue Imageability			
Task	Base	High	Low	High	Low
RGT	1%	16.15%	18.15%	16.17%	15.90%
ABMT	NA	1.0%	5.0%	0.6%	2.3%

Key. ABMT = autobiographical memory task and RGT= random generation task, NA = not applicable

Discussion.

Previous studies have suggested that central executive function is involved both in the storage and retrieval of autobiographical memories. This study aimed to examine the effect of retrieving specific and general autobiographical memories on a random keypressing task. It was predicted that the retrieval of specific autobiographical memories is a more effortful process than the retrieval of general memories and that by increasing the number of cues used in all memory trials, this effort would be reflected by the corresponding decrement in the randomness of a keyboard version of the traditional random generation task.

The results however did not show any significant difference in randomness when participants were retrieving a specific versus a general memory. As in Experiment 7 (a) a significant difference in randomness was demonstrated between baseline trials and autobiographical memory trials. Two different measures of randomness were used in this experiment, and significant differences in randomness between baseline trials and autobiographical memory trials were shown using Evans index of randomness (RNG), and a triplet measure. These findings are consistent with previous studies on randomness (Rosenberg et al 1991) and supports the findings in Experiment 5 that both Evans index of randomness and a 'triplet' measure are sensitive to changes in randomness. No significant changes in randomness were shown by either measure between the retrieval of specific and general memories. Also giving participants more cues to respond to in each memory trial and increasing the processing demands of the primary task made no difference to performance on the keypressing task. Overall the results did not support the prediction that the recall of specific autobiographical memories is more effortful than the retrieval of general autobiographical memories.

Analysis of omissions made by participants when performing the autobiographical memory task and the random generation task suggests a trade-off strategy between both tasks. Firstly in the autobiographical memory task participants had significantly more omissions when they were requested to retrieve specific memories in response to low imageable cues. This trial condition was predicted to be the most difficult and the increased omissions on such trials reflects the effort involved in retrieving a specific memory to a low imageable cue. Such omissions may have enabled participants to maintain performance on the random generation task during completion of the autobiographical memory task in these particular trials.

The pattern of retrieval of autobiographical memories following general instructions in response to high and low imageable cues also reflects particular strategies. There was no significant difference between the total number of general memories retrieved following general instructions to high and low imageable cues. However when general memories were sub divided into categoric/extended memories and semantic autobiographical memories, it was found that significantly more semantic memories were retrieved to low imageable cues than to cue words high in imageability following instructions to be general. In trials where participants were instructed to be specific in response to low imageable cues, participants retrieved more categoric/extended memories and had an increase in omissions on these trials. This pattern of retrieval is consistent with a 'trade off' adopted by participants between performance on the primary autobiographical memory task and the random keypressing task. By opting to select memories further up the hierarchy of autobiographical memory, such truncated searches would suggest that participants were able to maintain performance on the keypressing task by the deployment of such retrieval strategies.

However, adoption of such retrieval strategies still does not explain why both experiments failed to reflect any decrement in randomness in the keypressing task when participants were instructed to retrieve a specific versus a general memory. Also, even when participants were given either high or low imageable cues to initiate search cycles, both experiments still failed to reflect any significant differences in the effort involved in the retrieval of autobiographical memories. Such findings raise a number of questions which are next addressed

Why was the secondary task unaffected by memory instructions? A possibility is that the retrieval of general memories necessarily involves less effort when compared to the retrieval of specific memories. It has been argued that retrieval of general memories is less effortful than the retrieval of specific event memories since such memories are situated at a higher level in the hierarchy. In addition, generic recall is typically seen as functionally adaptive in everyday discourse. Nevertheless, it is possible that utilising a cue word paradigm and requesting participants to retrieve general memories was not necessarily any easier than the retrieval of specific memories.

Participants may have found the goal of retrieving either a specific or general memory equally difficult. General memories may well be a default 'option' when specific retrieval fails, but strategically attempting to target a general memory may not require less effort. It is possible that it is the setting up of a retrieval plan (when a search cycle is activated by a cue word) that is effortful and dependent upon adequate attentional resources.

Central executive resources and the supervisory attentional system have been closely identified with the initiation of goal directed behaviour. The planning (and execution) of such goal directed behaviour when the target is either the retrieval of a specific and general memory may involve comparable effort to implement the plan. If we examine our earlier model of retrieval in autobiographical memory, the retrieval plan sets in motion the different elements of Williams & Hollan (1981) retrieval search cycle; (find a context-search and verify). This argument assumes that it is the active setting up of the target plan involving indexing and context linked structures and the final verification of output at the end of the cycle that is inherently effortful. Indeed it can be argued that such processes are actually relatively more effortful than the actual running of the search process. When a target memory is deemed to have satisfied the experimental demands be it a general or a specific memory, a response is made and it is the sum of all these processes that involves effort.

Since identification of the target prior to search and verification of the target following a search (whether a specific or a general memory) involves equal and comparable amounts of effort, performance on the keypressing task remains constant across all conditions. According to this argument, the nature of the target whether specific or general is irrelevant though imageability of the cue initiating the system determines what retrieval strategies or trade offs are adopted as previously discussed.

An argument against such a model of retrieval reflecting the similar effort involved in retrieving either a specific or a general memory is that is that it does not explain why participants opt to retrieve a semantic memory instead of a general memory when instructed to be generic, or a general memory when instructed to be specific. If the goal of a retrieval plan is to retrieve a particular type of memory, presumably the retrieval plan is not implemented until such a target is chosen. Such changes in strategies could be initiated at the evaluation phase of the retrieval cycle following repeated failures to verify the required output, but these strategies would presumably be more effortful and involve more recursive cycles and should be reflected by the corresponding decrements in randomness.

A second explanation to account for the failure of the secondary task to reflect the effort involved in the retrieval of specific autobiographical memories is that the keypressing task may not be sensitive to retrieval processes from long term memory. Such an explanation was briefly considered in relation to the findings of experiment 7 (a). While the results of the digit span task would suggest sensitivity to working memory load, and the nature of omissions on the digit span task further reflects the sensitivity of the task to variations in processing loads, retrieval of information from long term memory is not the same as a digit span task which involves short term phonological storage. Also while the results of the digit span task suggested that the random keypressing task was not modality specific and that a general all purpose central executive system was responsible for activating and maintaining knowledge in working memory, it is possible that the retrieval of autobiographical memories either involves structures other than the central executive or distinct processing units within the executive system itself which are not affected by a random keypressing task.

The results of neuropsychological research on normal subjects (Levin et al 1991; Welsh et al 1991) and brain injured patients (Shallice & Burgess 1991,1993; Van der Linden 1992) suggest that there is not a *unitary* central executive. Rather, there appears to be several control functions which may operate independently. It has been argued that it is difficult to find an appropriate test to measure central executive function and if such a system is fractionated this problem is compounded. Problems arise for tasks used in concurrent task methodology for isolating the involvement of memory components in various tasks. For example random number-letter generation used by Gilhooley et al (1993) interferes with syllogistic reasoning performance in a way that articulatory suppression and tapping to a preset pattern do not. Moreover using random number-letter generation involves prior knowledge - in the form of stereotypical sequences and acronyms (BBC, DHSS, counting etc). Overall it is difficult to find a task that provides an indicator just of central executive capacity.

Arguments in favour of the sensitivity of the random keypressing task however stem from previous work with this task by Baddeley (1996). Significant decrements in randomness were found in a wide range of tasks by Baddeley et al (1996). Performance on the keyboard generation task was substantially interfered with by a concurrent verbal fluency task and a test of fluid intelligence. Both of these tasks are known to be sensitive to central executive function. Secondly a trails test that required constant switching of retrieval plans similarly caused substantial interference with random generation. Furthermore, given the similarity in the nature of retrieval plans implemented in the execution of the random generation task and in the retrieval of autobiographical memories, in terms of the monitoring of memory output and random number output it would appear that the random keypressing task should be sensitive to the retrieval of memories from autobiographical memory.

A third possible explanation of why experiments 7(a) and (b) failed to demonstrate significant differences in the randomness of the keypressing task following instructions to be specific or general is that the different conditions may have elicited different strategies, making use of flexibility in the way specific events may be accessed. It is possible that specific memories can exist as a separate memory pool distinct from the structured hierarchy (Conway 1990a, 1990b, 1992; Anderson & Conway 1993). If specific memories are stored in a separate memory store, access to such memories may be mediated by a process of direct retrieval which can by-pass the hierarchical structure. Thus, following activation by a cue word (especially cues which are high in imageability), a direct retrieval process may be initiated. In such a situation, the retrieval of specific memories would entail comparable amounts of effort as the construction of general memories. A direct retrieval hypothesis however must still account for the ability of participants to switch retrieval plans once a cycle is initiated.

If this were the case, then an important aspect of the 'direct retrieval' plan set up at the outset would be whether direct retrieval or indirect retrieval (via intermediate descriptors) is to be attempted. We suggest that the nature of the cue word is important in determining whether a direct retrieval cycle or a generative cycle is selected. Generative cycles typically involve a trawl through the hierarchical knowledge structures where lifetime events index general events. Low imageable cues are less likely to activate a direct retrieval strategy and instead activate a generative retrieval cycle. This model is depicted schematically in Figure 11.5.

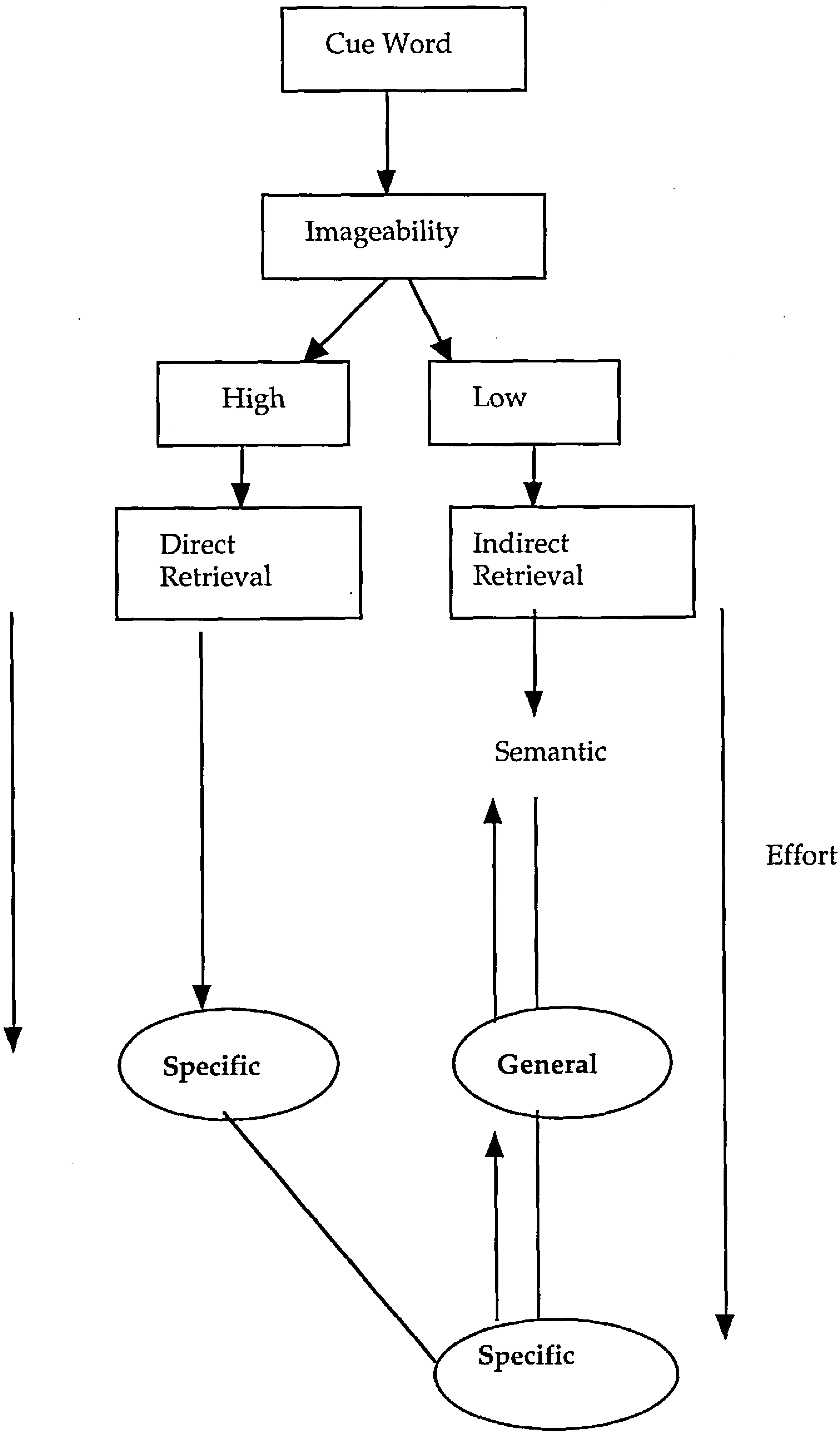

Figure 11. 5. Model of direct and indirect retrieval in autobiographical memory

Faced with a difficult task such as the retrieval of a specific memory in response to a low imageable cue, participants strategically traverse through the different knowledge structures and retrieve the next best memory that they feel will satisfy the experimental constraints and opt for a general memory. Such a strategy accounts for the pattern of retrieval found in the last two experiments. The increase of omissions following specific instructions in response to low imageable cues reflects the difficulty of this task whereas following general instructions to low imageable cues participants retrieve significantly more semantic type of memories, responding with the intermediate cues that were active in working memory as the generative retrieval cycle takes place.

Such a direct retrieval hypothesis would thus suggest that direct retrieval of specific memories involves less effort than predicted resulting in constant performance in the keypressing task. The strategic selection of strategies determined by the nature of the cue word also account for the pattern of retrieval which assumes flexibility and adaptability in the retrieval process.All of the above explanations will be considered in Chapter 12 in the light of earlier experimental results.

Chapter 12

General Discussion.

While much of the early work with depressed and suicidal patients has concentrated on possible causes and correlates of non specificity in the retrieval of autobiographical memories, there have been few attempts to understand the processes and mechanisms underlying this specific - generic continuum. The overall aim of this thesis was to examine those mechanisms that underlie the production of specific and general autobiographical memories in non clinical groups. The roles of imagery and working memory were examined in relation to these mechanisms.

Experiment 1 showed that variation in imageability of cue words could mediate the retrieval of specificity in autobiographical memory. This finding is consistent with that of Williams & Dritschel (1988) who suggest that rich contextual cues may overcome categoric or general memory retrieval by facilitating access to specific events. Experiment 2 further confirmed these findings when a range of cue words differing in imagery modalities were used to cue autobiographical memories. Abstract or low imageable cues resulted in the retrieval of general memories and prolonged retrieval times when compared to cues that were high in visual, olfactory, tactile, auditory and motor imagery. No significant differences in autobiographical memory specificity were found between the latter sensory modalities. Multiple regression analyses however suggest that visual imageability was the most significant predictor of specificity in autobiographical memory. Auditory imagery also emerged as a significant predictor although to a lesser extent than visual imageability.

Imageability was used to manipulate retrieval style in a third experiment. Participants were presented with high and low imageable cues and requested to retrieve events from their past as part of an induction phase. Subsequently when participants were asked to generate images of the future in response to cues, they responded with more specific or more general images depending on the type of memory they had retrieved in the induction phase: Induction of a generic retrieval style reduced the specificity of images of the future. This finding is consistent with the way depressed and suicidal groups imagine future events (Williams et al 1996) and suggests that memory retrieval and future imaging may share common pathways.

Strategic retrieval of specific events from autobiographical memory is enhanced by cue words high in imageability. While imageability is a potent variable, how the beneficial effects of this variable are implemented remain uncertain. Several techniques have been developed to measure the amount of imagery elicited by words. One is based on 'imagery value' a notion which has been shown empirically (Cornoldi & Paivio 1982; Paivio, Yuille & Madigan 1968). The imagery value of a word is defined by its capacity to elicit a mental image in a person's mind. Operationally it is defined as the mean rating assigned to a word by a group of participants on a scale which ranges from ' no image' to 'very clear and vivid image'. Ratings show a high degree of inter and intra reliability and word imagery value is generally regarded as a valid reflection of the imagery activity elicited by words.

The extra sensory perceptual information and memory specificity stimulated by cues high in imageability may also access knowledge based stores. Denis (1983) proposed that the imagery value of words can be predicted on the basis of the richness of the corresponding concepts in figural semantic features. Such a hypothesis offers an alternative account of imagery effects. Similarly Kieras (1978) proposed a knowledge based account of imagery effects and proposed that high imageable words contain more semantic attributes than low imageable words. These semantic attributes are assumed to reflect differences in the semantic structure attached to the words. This alternative account of imagery effects was investigated through the use of a predicability measure proposed by Jones (1985,1988) and its effect on the retrieval power of cues used in the autobiographical memory tasks.

Predicability measures of cue words used in the investigation of autobiographical memory was thus an important variable to explore in terms of the retrieval power of the cues used. Both objective and subjective measures of predicability were obtained for all cues used in the autobiographical memory task. A highly significant correlation was obtained between imageability ratings and predicability measures. This finding is consistent with previous work by Jones (1985,1988) and Denis (1983,1991). However regression analyses suggested that predication time was a significant predictor and contributed most of the variance in the specificity of autobiographical memory. Thus the imagery value of a word possibly depends upon the richness of the corresponding concept in semantic terms and the concepts richest in semantic features are also highly imageable. It is this aspect of cues which facilitates access to specific event memories in autobiographical memory.

In summary the notion that cue words low in imageability and predicability are poor retrieval cues has been empirically demonstrated in the first three experiments. It was argued that greater effort is required to generate specific memories to such degraded low imageable cues and that less effort is needed when high imageable cues are used to cue autobiographical memory. The amount of effort available depends upon central executive resources which monitor and regulate retrieval of autobiographical memories (Shallice 1980; Conway 1992, 1993, 1996; Williams 1992, 1996). Reduced central executive capacity has also been suggested as a contributor to the production of overgeneral memories in depressed and suicidal groups. An index of effort however was necessary to identify the processing capacity needed to retrieve either a specific or a general memory and directly link autobiographical memory function to that of working memory and central executive.

Experiments 6(a), 6 (b), 7 (a) and 7 (b) aimed to study the effects of divided attention on retrieval from autobiographical memory. A keyboard version of the original random generation task was used as a secondary task to measure central executive function. It was proposed that generating random number sequences and attempting to recall past events share common features in terms of setting up retrieval plans and monitoring randomness or memory output to satisfy experimental constraints. Both processes can be regarded as functions of the central executive component of working memory and compete for similar resources. Having participants perform both tasks simultaneously provided an index of the degree of effort required for the primary task of recalling either specific or general memories. Since the random generation task was central to the dual task paradigm, Experiment 5 examined the processes underlying the production of random sequences.

Given the complexity of randomness and suggestions that one single parameter may not capture the complexity of this measure, a number of other measures of randomness were also included. Basic biases in subjective perceptions of randomness were reviewed by Wagenaar (1972). Humans tend to produce sequences that have too few symmetries and long runs. There are too many alternations among events and too much balancing of event frequencies over relatively short regions. It is a widespread belief that randomness excludes immediate repetitions and Evans (1978) similarly noted that subjects tend to avoid immediate repetitions in random production.

Experiment 5 compared random sequences generated by humans, those produced in published tables and two versions of computer generated sequences using different programs. Six different measures of randomness were used to assess the randomness of the sequences; Phase, Triplets, Mean Difference, Autocorrelation, Chi Square and Evans Randomisation Index. All four sources of random sequences were compared across all six measures. The results showed that the randomness of sequences generated by humans was significantly less than those generated by other sources when assessed by both the triplet and Evans measure. These results replicate those of Rosenberg (1990) who similarly compared computer simulated sequences with those of humans.

Two predictions employing the non verbal version of the random generation task were examined in experiment 6; firstly that random keyboard generation utilises general processing capacity and thus is not modality specific, and secondly that the effect will increase systematically with memory load. Subjects attempted to generate random keypresses in response to a one second interval tone, while remembering digit sequences varying in length from zero to eight. As predicted randomisation decreased systematically with the length of the concurrent digit sequence. This is consistent with the notion that a keyboard version of the random generation task utilises general processing capacity and the generation of random sequences is not modality specific.

Experiments 7 (a) and 7 (b) examined the effects of random generation on the recall of specific and autobiographical memories. In emotionally disturbed groups it has been suggested that the 'mnemonic interlock' phenomenon results in a truncated search which is responsible for overgeneral memory responses. This is consistent with the suggestion of Ellis & Ashbrook (1988) and Hertel & Hardin (1990) that depressed people show poor memory partly because of limited resources. It was predicted that the recall of specific autobiographical memories may be more effortful than the recall of general memories and this would be reflected by a larger decrement in the randomness of keypressing trials.

However results showed no significant difference in the randomness of keypressing when participants were instructed to recall specific versus general memories. A significant difference was found between baseline trials and all autobiographical memory trials whereby the randomness of baseline trials was significantly greater. However the retrieval of autobiographical memories was affected by the secondary task with a reduction in specificity when participants were instructed to retrieve specific memories in response to low imageable cues and perform the keypressing task concurrently. This suggests that individuals were able to truncate the memory search, trading off performance on both tasks. A modified retrieval strategy was adopted when impoverished low imageable cues were used to direct the memory search.

However, this truncated search hypothesis does not explain why no difference was found in the secondary task when participants were encouraged to truncate a search by explicitly instructing them to retrieve a general memory. A dual route model of retrieval was proposed to account for such findings. Before discussing the implications of this model and the role of images in the retrieval of autobiographical memory, some limitations of these experiments are addressed.

Limitations.

Firstly the cue word paradigm was used in all experiments, whereby participants are given cue words and asked to produce an associated memory from any period in their lives in response to a particular cue. This paradigm has been a popular and widely used tool in the study of autobiographical memory. It was originally devised by Galton (1879) and subsequently modified by Crovitz & Schiffman (1974). The development of the Crovitz technique for studying personal memory has given rise to extensive literature (Robinson 1976; Rubin 1982; Rubin, Wetzler & Nebes 1986; Williams & Broadbent 1986; Conway 1987, 1990, 1992, 1993).

Despite the evident fruitfulness of these studies, the assessment of autobiographical memory by such techniques has difficulties. Rabbitt & Winthorpe (1987) examined weaknesses in the Galton/Crovitz paradigm and argue that the search initiated by such cues is unevenly distributed across the life span. When cue words are provided, each successive event recalled will also tend to elicit associated memories from the same period. Thus because participants are not constrained to produce memories from specified time periods, the temporal gradient obtained may reflect a participant's bias to recollect memories from a particular time period rather than their capacity to do so.

Limitations of the cue word technique have also been echoed by Baddeley & Wilson (1986) and Kopelman (1994, 1996). Furthermore, use of this technique concentrates on strategic recall of autobiographical memories. It seems unlikely that in everyday cognition, people encounter single words out of context, which lead to the retrieval of past events. It is more likely that an event or aspect of an event reminds a person of a thematically related past events. Another feature of everyday cognition is that memories tend to 'pop' into mind (Salaman 1971), and the cue word technique is possibly a blunt tool to investigate such non strategic retrieval in autobiographical memory.

While the limitations of the cue word paradigm are of particular importance in studies with elderly groups and in assessing the effects of brain lesions, the cue word technique has been widely used in clinical groups where the strategic retrieval of specific memories is precisely the aspect of memory being studied. The cue word technique has the added advantage that the nature of the cue word can be systematically varied to examine its effect on subsequent memory retrieval. Studies in clinical research have typically used positive, and negative emotive cues and also neutral cues and activity cues. Furthermore, autobiographical memories retrieved to cue words also provides useful information about the organization and structure of autobiographical memory (Conway & Bekerian 1987; Conway 1990, 1992, 1993, 1995). A particular word, for example can remind one of a thematically related past event and Schank (1982, 1986) reports that specific themes may act as potent cues to memory constructions. In summary the cue word paradigm, despite its narrow focus, is a useful tool in the study of autobiographical memory where manipulations of memory retrieval in terms of specific and general memory are the primary concern.

A second limitation in these studies is that no attempt was made to take account of individual differences in working memory capacity, and it was not possible to examine individual differences in retrieval from autobiographical memory and working memory. Winthorpe & Rabbit (1988) found that elderly participants who had reduced working memory capacity (assessed using the sentence span task) were more likely to be generic in their recall of events from their lives. The assessment of working memory capacity either by Daneman (1980) sentence span task or a modified version of this task by Engle (1993) would be a useful index in comparing working memory capacity to memory specificity and overall performance of participants in the dual performance tasks.

A third limitation concerns the nature of the dual task paradigm. Dual task performance as examined in experiments 7 (a) and 7 (b) is problematic in that it was not possible to monitor participants strategies during the tasks. Previous studies have used POC (performance operating curves) to monitor performance during trials. A characteristic approach in the multiple resource literature is to examine the effects on performance of systematically varying the demands of the individual tasks or systematically varying the amount of attention which subjects are requested to devote to each task. By these means it is possible to plot performance resource functions for each task (Wickens 1984, 1992) with performance plotted against task demand. It is also possible to plot the performance of one task against the performance of the other concurrent task at different levels of task demand or task allocation.

There is growing awareness of the importance of trade off functions both within task (e.g. speed, error trade-offs) or in dual task performance between the performance of the two tasks (Navon & Gopher 1980). For this reason plotting performance operating curves is deemed highly advisable to detect the influence of a secondary task on the relevant components of memory. This technique has been widely used in attention literature but has not been applied to the dual task co-ordination hypothesis in working memory. While a number of trade-offs were identified in Experiment 7 in terms of omission scores and performance on the primary task, a performance operating curve is necessary to precisely identify strategies and performance in the dual tasks. Future work could vary the demands of the individual tasks to investigate effects on subsequent performance. Despite these limitations, the pattern of data emerging does allow some preliminary conclusions to be made regarding the processes that underlie specificity in autobiographical memory. The following section discusses the implications of these findings and also examines the implications of the findings for studies of autobiographical memory in clinical groups.

The role of imagery in autobiographical memory.

Autobiographical memories typically involve imagery and the retrieval of sensory information (Brewer 1986; 1988; Conway 1988;1990; Johnson, Foley Suengas & Raye 1988). A central theme of this thesis is that cue words high in imageability readily access specific memories in autobiographical memory. The question remains however what aspects of imageability mediate this process and how can the effects of imageability on memory specificity be linked to a model of memory retrieval in autobiographical memory? Secondly do such findings have any relevance for clinical studies?

Images represent summary information in autobiographical memory which can be used to direct memory searches. Images (particularly high imageable cues) contain information which is maximally informative about a represented event in the sense that information in the image facilitates access to other related events and themes. The image itself, particularly those retrieved in response to high imageable cues may also be accessed with the minimum of cognitive effort. The information contained in an image may be employed as a source of powerful cues by retrieval processes, with which to probe memory traces. Protocols provided by a number of subjects indicate that information in images can be elaborated upon in order to access further information related to an event (Whitten & Leonard 1981).

Such evidence suggests that images may be employed to search complex memories and that images facilitate access to information within a complex memory trace. This argument was advanced by Conway (1988) who suggested that a major function of imagery is to facilitate memory retrieval in autobiographical memory. If images do contain information which can be exploited by retrieval processes to construct a specific memory, it must correspond to similar information stored in other parts of memory (Tulving & Thompson 1973). To be effective retrieval cues, images should represent information which maps onto many parts of a memory trace. Thus cues high in imageability which are also rich in semantic attributes and predicates readily access specific memories. How does this fit with models of retrieval in autobiographical memory?

Generative retrieval is based directly on Williams & Hollan's (1981) 'cyclic' model of autobiographical memory retrieval. Three interdependent phases have been identified in the generation of an autobiographical memory. The first phase 'find a context' or find a 'memory description' (Norman & Bobrow 1979) is constructed. The nature of the cue word is a critical determinant at this point in the retrieval cycle as the type of intermediate descriptions or contexts initiated depend upon the cue word. High imageable cues are maximally informative and map onto a rich array of intermediate descriptors and indices during the retrieval process.

According to this model, cues high in imageability are readily elaborated into additional memory contexts which are subsequently used to search memory. Such elaborations may include work themes, people, places and activities. Having selected a particular context, this description or retrieval plan is used to search memory; the second phase of generative retrieval. Once a memory is retrieved, this output is evaluated in terms of the original context and experimental constraints. The aim of the evaluation phase is to determine whether or not the retrieval phase can be terminated and a response executed.

Proponents of hierarchical structure in autobiographical memory suggest that most cues available at the general event level will correspond to a whole series of records which are temporally contiguous with the period specified by the general event. Thus a cue will tend to activate many records and, if highly imageable contains the potential to activate many more. Indeed Conway (1992) assumes that the specific processing context in which a cue is utilised determines which memories are accessed from the total pool of available memories. All of these constraints are implemented at the running of the retrieval plan. According to a direct model of retrieval previously discussed high imageable cues can also readily access specific memories directly and by-pass the indirect retrieval process.

The memory specificity effects mediated by high imageable cues can be compared to the concreteness effects mediated by imageability in verbal learning paradigms. A number of different mechanisms have been proposed to account for such findings. The first of these assumes that cues high in imageability contain more information than those of abstract words. The results of experiment 1 are consistent with the findings of de Groot (1989) who investigated the roles of word imageability and frequency on 'm' (the number of responses generated to a stimulus word within a pre specified amount of time in continued word association). Larger 'm' scores were obtained for concrete high imageable words than for low imageable words suggesting that concrete words contain more information than abstract words.

Both Kieras (1978) and Schwanenflugel & Shoben (1983) proposed a similar context availability hypothesis whereby the number of possible contexts for a word might be the 'true' source of imagery effects in memory and that concrete or high imageable words had greater contextual variety. Thus using high imageable cues to assess specificity of recall in autobiographical memory enhances and facilitates that process. Predicability measures on all cues used provides further support for a knowledge based account of cues high in imageability. Significant correlations were obtained between high imageable cues and high predicability ratings, suggesting that the more information contained within a cue the more efficient that cue is as retrieval probe and at accessing related information.

A further mechanism which could account for the effects of imagery on memory specificity relies on Paivio's dual coding theory (DCT; Paivio 1971,1986,1991). DCT assumes the activation of imaginal and verbal representations through referential interconnections between the two systems and associative connections within each system. Hence a high imageable word for example 'mountain' readily accesses memories of past actions, similarly memories of such events are readily accessible in an imaginal form, which is easily described as a specific memory. Such processes account for the separate and joint contributions of non-verbal (imaginal) and verbal representations and processes.

One of the primary forms of indexing within a structural model of autobiographical memory is by means of personally relevant themes (Conway 1992a; Robinson 1992). Anderson & Conway (1993) found that distinctive memory details provided the fastest access to specific autobiographical memories. Such distinctive details are initiated by high imageable cues and in turn are associated with and instantiate personally relevant themes. Access to specific events in memory retrieval is via a distinctive image or detail plus contextualising details 'the distinctive chunk' (Anderson & Conway 1993). Further cues or relations generated from knowledge in this distinctive chunk are used to probe memory for additional details.

Marschark & Hunt (1989) proposed an alternative model to DCT which may be relevant for the functional role of imagery in autobiographical memory retrieval. They applied their theoretical framework to concreteness effects in memory for word pairs. They proposed that memory for any response word from a paired associate list depends upon the activation of both relational and distinctive information at encoding. If reactivated at retrieval, the relational information serves to delineate a search set of word pairs, and distinctive information is used to retrieve more precise discrimination of the target pair and response word within that set. Among other sources perceptual information derived from imaginal processing at encoding "may serve either a relational or distinctive function at retrieval" (Marschark & Hunt 1989, pg.711).

They also particularly emphasised that imaginal processing induced by concreteness enhances distinctive processing. Similarly imagery effects in autobiographical memory with high imageable cues enhances subsequent retrieval of specific memories and distinctive memory details have been shown to provide the fastest access to specific autobiographical memories (Anderson & Conway 1993). The critical difference between the relational/distinctiveness theory and a dual coding model is that Marschark & Hunt (1989) assumed that concreteness induced imagery affects memory primarily by enhancing the distinctiveness of concrete words rather than by providing an additional memory code as postulated by Paivio (1971).

While all of the above mechanisms proposed to mediate the effects of imagery on memory specificity are difficult to separate, it is possible that they all jointly contribute additive effects to memory specificity. It is also likely that cues high in imageability can initiate all or some of the above strategies to facilitate memory retrieval. An important aspect of high imageable cues is precisely that they are versatile in that they can engage any one or all of the strategies outlined. On the other hand, low imageable cues are limited or constrained operating more like abstract words in paired memory tasks. They contain less information than high imageable cues and are as Barsalou (1982) described them context-dependent. With such impoverished cues, dual encoding of memories is constrained and distinctive or relational processing at retrieval is limited.

The task whereby participants were instructed to retrieve specific memories in response to low imageable cues and the resulting truncated searches is comparable to the difficulties experienced by clinical groups in constructing specific autobiographical memories. It was predicted that the retrieval of a specific memory is inherently more effortful than the retrieval of a general memory, and that an index of such effort as measured by the random keypressing task would reflect such a process. Hierarchical models of autobiographical memory assume that general events index specific events. Inherent in this model is the notion that the retrieval of specific autobiographical memories is more effortful as specific memories form the lowest level in the hierarchy and more effort is required to initiate recursive search cycles between and within the partonomies and levels of knowledge in autobiographical memory. Why then, was no difference found in secondary task performance when participants were asked to recall target memories differing in their 'level' in the hierarchy?

One possibility is that the retrieval of both specific and general memories involves similar amounts of effort. According to this argument it is the active setting up of a retrieval plan involving indexing context linked structures and the final verification of output at the end of the cycle that is inherently effortful. The nature of the target memory or the goal of the retrieval plan is irrelevant, since the identification of the target prior to the search cycle and the verification of the target following the cycle (whether a specific or a general memory) involves comparable effort. Thus by implementing such a retrieval model, the randomness of the secondary task remained constant when participants retrieved either a specific or a general memory.

Such a model of retrieval however failed to account for the particular retrieval strategies adopted. When participants failed to retrieve a specific memory following instructions to do so, they opted for a general memory. Similarly participants tended to opt for a semantic memory when unable to retrieve a general memory when instructed to be generic. If the goal of a retrieval plan is to retrieve a particular type of memory, presumably such a retrieval plan is not implemented until the required target is identified. Failure to verify the target memory at the end of the search cycles could initiate more recursive cycles but such repeated running of retrieval plans would be more effortful and be reflected by a corresponding decrement in the randomness of keypressing.

Another explanation to account for the failure of the secondary task to reflect the predicted differences in effort involved in the retrieval of specific versus general memories was that the keypressing task may have been insensitive to processing demands in the retrieval of information from long term memory. Arguments against the insensitivity of the secondary task however stem from the result of the digit span task which showed a significant decrease in randomness with increasing memory loads. The sensitivity of the keypressing task was also reflected by the pattern of omissions scores in this task with the greater number of omissions occurring on trials where participants recalled 8 digits. Furthermore, previous work by Baddeley (1996) with this version of the random generation task demonstrated significant decrements in randomness in a wide range of tasks. Finally given the similarity between the random keypressing task and the autobiographical memory task in the implementation and execution of retrieval plans, it is was thought unlikely that insensitivity of the secondary task accounted for the failure to show the predicted differences in randomness in the autobiographical memory trials.

A further explanation to account for the results of experiments 7 (a) and 7 (b) which may be preferable is that specific memories may be accessed by routes other than those assumed by hierarchical models. It is possible that specific memories can exist as a separate memory pool, accessible by routes other than via the structural hierarchy. This has previously been proposed by Conway (1990a, 1992, Anderson & Conway 1993). Following activation by a cue word (especially cues which are high in imageability) a direct retrieval process may be initiated. In such situations, the retrieval of specific memories would be less effortful and comparable to the retrieval of general memories.

I suggest that the nature of the cue word is an important determinant in the selection of a particular retrieval strategy. Cues low in imageability are unlikely to initiate direct retrieval strategies to access specific memories and instead activate an indirect generative retrieval cycle. Such a strategy might account for the pattern of retrieval demonstrated in experiment 7 (b). This dual route model of retrieval is shown in Figure 12.1.

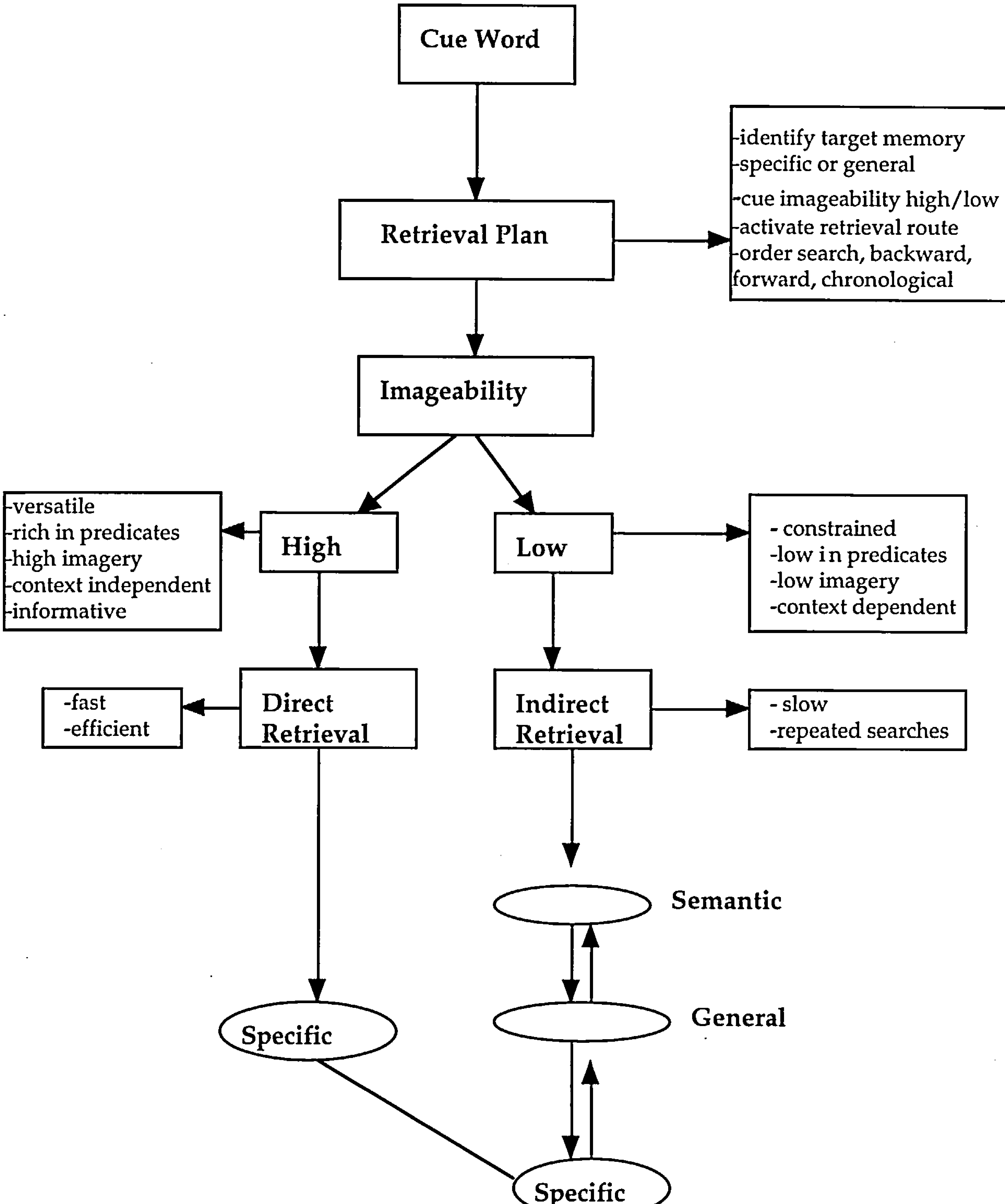

Figure 12.1. Model of direct and indirect retrieval in autobiographical memory

A direct retrieval hypothesis would thus suggest that the retrieval of specific memories involves less effort than previously predicted resulting in constant performance in the keypressing task. Consider the retrieval cycle that would be initiated in response to a cue such as 'mountain'. As previously discussed highly imageable cues are maximally informative and are readily elaborated into appropriate memory contexts. The speed with which a response such as 'the day I climbed Snowdon' is recalled is consistent with highly distinctive imageable memories of events being stored as records in a separate memory pool and accessed directly with the minimum of effort. Such memories have probably been frequently recounted and rehearsed and the images of such an event readily evoked. In contrast there are very few if any single event records of memories that are activated by low imageable cues and thus an indirect generative retrieval cycle is initiated involving repeated recursive search cycles.

How does the above model and the results of the imagery studies previously described fit in with the findings from clinical groups? The adoption of such alternative retrieval strategies as described above can be linked to the failure of depressed and suicidal patients to retrieve specific autobiographical memories. I suggest that the model of retrieval adopted by depressed and suicidal groups is comparable to that of participants when instructed to retrieve specific memories in response to low imageable cues. Clinical groups have difficulties which bear similarities to that of normal groups trying to initiate a memory search with low imageable cues. It is possible that for clincial groups all cues are impoverished and constrained and they are unable to avail of maximally effective retrieval strategies when they are operating with such cues.

This failure to engage effective strategies in a range of other memory tasks from recognition tasks to verbal learning has been demonstrated in depressed groups. There are indications that clinical depression is associated with poor recall of prose on both free recall and cued recall tests (Watts & Sharrock 1987). Furthermore the effects of depression on structural aspects of prose recall was explored by Watts & Cooper (1989) and the results were consistent with the hypothesis that depressed patients do not use structure to organise stories when encoding them. In addition research reported by Hertel & Rude (1991) suggests that depressed people are capable of performing effortful procedures only when the task requires them to focus attention.

This is consistent with the view that the failure of depressed and suicidal groups to retrieve specific memories of past events is partly attributable to their inability to engage the mechanisms by which imageability effects mediate the construction of specific memories (image generation, context availability and the richness of semantic information). Previous accounts of memory deficits in clinical groups have relied on positing reduced processing resources (Ellis & Ashbrook 1988b) to explain such findings. Such reduced working memory capacity is compounded in clinical groups by repeated failures to engage strategies which would enhance the retrieval of specific memories: they fail to engage the 'dual route' model to maximum effect.

Clinical groups owing to current preoccupations, tend to regard both high and low imageable cues as impoverished and constrained cues. This tendency in turn activates indirect retrieval search strategies, resulting in a failure to access specific event memories. The truncated search following repeated failures to access a specific event sets up a further negative cycle of rumination resulting in 'mnemonic interlock' (Williams 1994, 1996). Is there any evidence for this supposition?

Firstly, previous work has shown that stimulus independent thoughts are heavily dependent upon central executive resources (Teasdale et al 1993). Stimulus-independent thoughts are streams of thoughts and images unrelated to immediate sensory input, and are similar to the worrisome intrusive ruminations that preoccupy depressed and clinical groups. The production of such thoughts and images that depend upon central executive resources suggests that because of reduced capacity clinical groups are unable to initiate strategies that are maximally effective (such as direct retrieval routes to access specific event memories).

Secondly, work by Kuyken & Brewin (1996) show that depressed patients who score highly on an Impact of Events Scale (IES)[1] were significantly more likely to retrieve general memories compared to those with lower scores. The fact that finding more generic memories in those with the greatest frequency of current preoccupations is consistent with such patients adopting indirect retrieval search cycles which facilitate truncated searches. Figure 12.2 shows a schematic representation of this model of retrieval in clinical groups Adopting avoidance strategies and the presence of intrusive and negative thoughts, in addition to depleting available resources encourages repeated indirect retrieval search cycles which in turn prevents access to specific memories of past events.

---

[1]The Impact of Events Scale (IES) is a 15 item scale consisting of two subscales. This scale includes questions about the impact of a traumatic event, the degree of intrusions and in addition questions about avoidance measures taken.

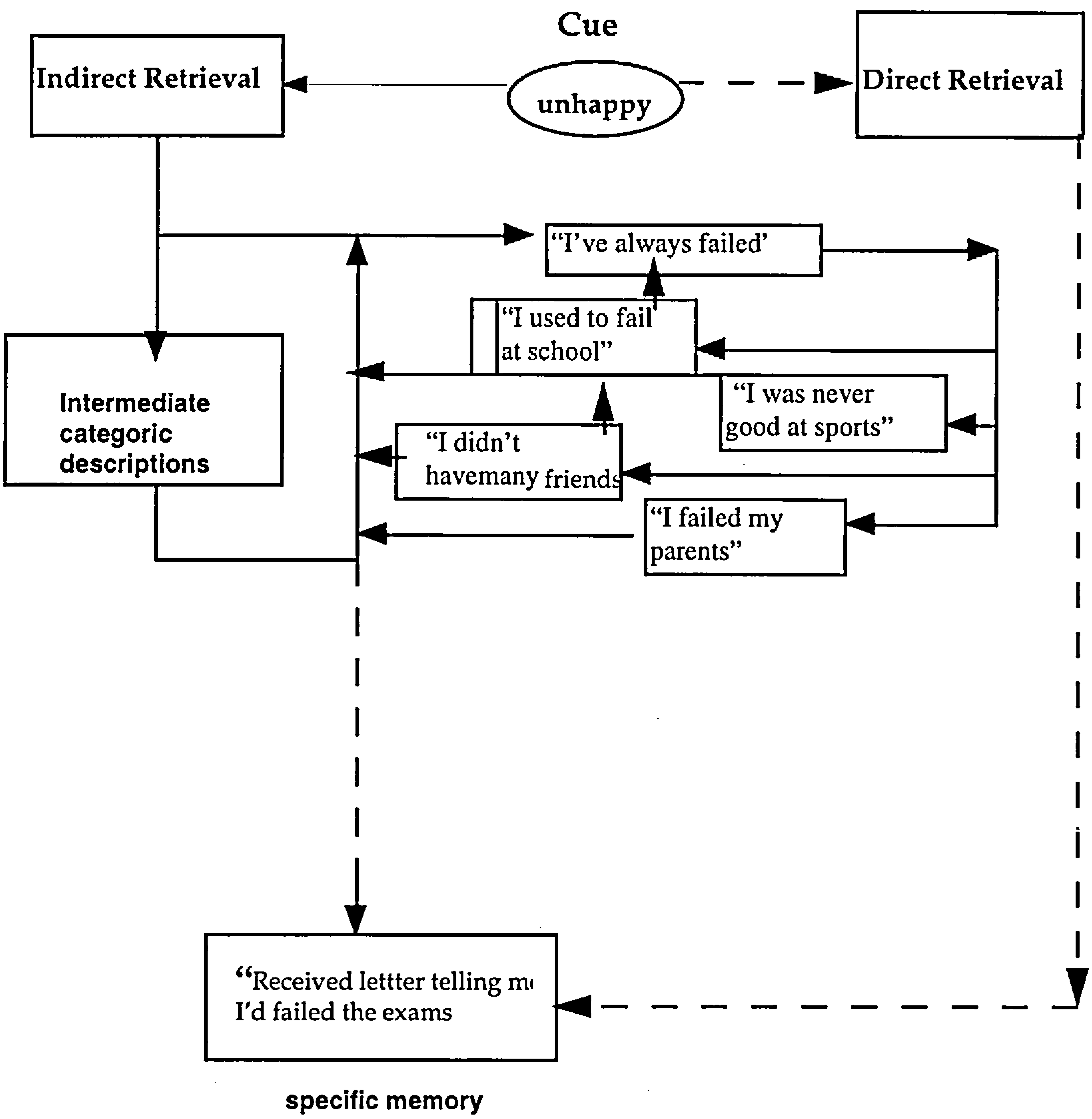

Figure 12.2. Indirect retrieval cycles engaged in and maintained by clinical groups.

Postulating a dual route model of retrieval in autobiographical memory and the suggestion that clinical groups tend to initiate indirect retrieval search cycles is also consistent with other strategies they may adopt. The maintenance of repeated recursive search cycles may enable such groups to maintain strategic passive avoidance of unpleasant and painful memories. Consider the retrieval pattern depicted in Figure 12.2, if the specific memory (receiving the letter informing the subject she had failed the exam) is activated upon hearing the cue 'unhappy' such a memory is clearly painful and rather than recount the details surrounding that particular event, the subject may choose to strategically initiate an indirect retrieval route which enables him/her to avoid recalling that particular memory.

The present findings suggest that future investigations into the specificity of autobiographical memory in clinical groups should further explore the role of working memory. Previous studies have not measured working memory capacity in relation to autobiographical memory in depressed patients. In order to examine how clinical groups treat high and low imageable words, as retrieval cues, a number of predicability measures could be examined. Reduced predicability scores on high imageable cues would provide some limited support for the notion that clinical groups tend to regard both high and low imageable cues as equally impoverished, and thereby resulting in the use of an indirect mode of retrieval.

The dual route model described has evolved in an attempt to explain the pattern of results obtained. The model is speculative and its tentative nature warrants futher experimentation to test its value. Future experiments could include examining predicability measures in depressed groups when they are presented with high imageable cues and as discussed above reduced scores could provide some support for this model. To further examine the retrieval strategies adopted by depressed groups. verbal protocols would be a useful measure to track particular routes of retrieval.

The present findings also have implications for the design of interventions directed at the control of retrieval strategies in clinical groups. The findings suggest that the most effective means of accessing specific memories maybe by the use of imagery techniques and mnemonics. Encouraging clinical groups to use verbal protocols while retrieving autobiographical memories may also help to control which retrieval route they engage. Overall, the aim of such interventions in a clinical context is to maintain goal directed behaviour in the specificity of autobiographical memory recall.

Conclusions

Both imageability and working memory have been identified as important determinants of specificity in autobiographical memory. Manipulating retrieval by varying the imageability of the cue word has revealed different retrieval strategies by which specific and general event memories are recalled. The pattern of retrieval identified is consistent with hierarchical models of memory but also suggests that there are other routes to accessing specific memories. The indirect retrieval hypothesis which is initiated by low imageable cues provides a useful model for the mechanisms underlying the failure of depressed and suicidal groups to retrieve specific memories. Furthermore the findings in this thesis confirm that autobiographical memory is subject to the same influences as other forms of memory in terms of capacity constraints in working memory and the imageability effects which match those found in verbal learning paradigms. Autobiographical memory is an important aspect of cognition and psychological well being and combining research in clinical groups with non clinical populations and with more general investigations of memory is a fruitful direction for future research.

Anderson, J.R. (1976). Language, memory and thought. Hillsdale, NJ:Erlbaum.

Anderson, J.R. (1983), *The Architecture of Cognition,* Cambridge, MA: Havard University Press.

Anderson, S.J. & Conway, M.A. (1993). Investigating the structure of autobiographical memories. *Journal of Experimental Psychology: Learning Memory and Cognition*, Vol.19. No.5, 1178-1196.

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 Psycholofy of Learning and Motivation* , Vol.2, pp 89- 105. New York: Academic Press.

Atkinson, R. C. & Shiffrin, R. M., (1971). The control of short term memory. *Scientific American* , 225, 82 -90.

Baddeley, A.D. (1966a). 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. (1966b). The influence of acoustic and semantic familiarity on long term memory for word sequences. *Quarterly Journal of Experimental Psychology*, 18, 302-309.

Baddeley, A .D. (1966) The capacity for generating information by randomization. *Quarterly Journal of Experimental Psychology* 18,119-129.

Baddeley, A.D. (1981). The cognitive psychology of everyday life. *British Journal of Psychology*, 72, 257-269.

Baddeley, A. D., Thompson, N., & Buchanan, M (1975a). Word length and the structure of short term memory. *Journal of Verbal Learning and Verbal Behaviour,* 14,75- 589.

Baddeley, A.D., & Hitch, G. J. (1974). Working memory. In G. Bower (Ed), *The Psychology of learning and motivation*, Vol. V111, pp.47-90, New York Academic Press.

Baddeley, A.D., & Hitch, G. J. (1977). Recency re-examined. In Donic, S. (Ed.) *Attention and Performance*, Vol. 6, (pp647-667). Hillsdale, N.J: Lawrence Erlbaum Associates Inc.

Baddeley, A.D., & Levy, B.A. (1971). Semantic coding and short-term memory. *Journal of Experimental Psychology*, 89, 132-136.

Baddeley, A.D., Lewis, V.J., Eldridge, M., & Thompson, N. (1984). Attention and retrieval from long term memory. *Journal of Experimental Psychology, General.*, 113, 518-540.

Baddeley, A.D. & Wilson, B. (1986) Amnesia, autobiographical memory, and confabulation. In D.C. Rubin (ed), *Autobiographical Memory*, Cambridge, Cambridge University Press, pp. 225 -252.

Baddeley, A.D. (1986). *Working Memory*. Oxford: Oxford University Press.

Baddeley, A.D. (1990). *Human Memory: Theory and Practice.* Hove, UK: Lawrence Erlbaum Associates Ltd.

Baddeleu, A. D. (1992). What is autobiographical memory. In In M.A. Conway, D.C.Rubin, H. Spinnler and W.A.Wagenaar (eds), *Theoretical Perspectives on Autobiographical Memory.* Dordrecht, Boston & London, Kluwer Academic Publishers

Baddeley, A.D. (1993) Working memory and conscious awareness. In A.F.Collins, S.E.Gathercole, M.A.Conway, and P.E.Morris. (Eds).*Theories of memory*. Lawrence Erlbaum Associates.

Baddeley, A.D. (1996). Exploring the central executive. *The Quarterly Journal of Eperimental Psychology*, 49A, (1), 5-28.

Baddeley, A.D., Emslie, H., Kolodny,J., & Duncan, J. (in prep). Random generation and the executive control of working memory.

Bakan, P. (1960). Response tendencies in attempts to generate random binary series. *American Jouranl of Psychology,* 73, 127-131.

Barsalou, L. W. (1985). Ideals, central tendency and frequency of instantiation. *Journal of Experimental Psychology: Learning, Memory and Cognition*, 11, 629-654.

Barsalou, L.W. (1988). "The content and organization of autobiographical memories' In Neisser, U and Winograd, E. (Eds). *Remembering Reconsidered: Ecological and Traditional Approaches to the Study of Memory.,* (pp.193-243). New York, Cambridge University Press.

Bartlett, F.C. (1932) *Remembering: A study in Experimental and Social Psychology.* Cambridge, Cambridge University Press.

Basso, A., Spinnler, H., Valler, G., & Zanobio, E. (1982). Left hemisphere damage and selected impairment of auditory verbal short-term memory: A case study. *Neuropsychologia*, 20, 263-274.

Bauer, P.J., and Fivush, R. (1992). Constructing event representations: a foundation of variation and enabling relations. *Cognitive Development*

Beck, A.T., Brown, G. & Steer, R.A. (1989). Prediction of eventual suicide in psychiatric inpatients by clinical ratings of hopelessness. *Journal of Consulting & Clinical Psychology,* 57,309-310.

Bekerian, D., & Baddeley, A.D. (1980). Saturation advertising and the repitition effect. *Journal of Verbal Learning and Verbal Behaviour,* 19,17-25

Bower, G.H. (1981). Mood and memory. *American Psychologist*, 36, 129-148

Bjork, R.A., & Whitten, W.B. (1974). Recency sensitive retrieval processes.*Cognitive Psychology,* 6, 173-189.

Brewer, W.F. (1988). A qualitative analysis of the recalls of randomly sampled autobiographical events. In M.M. Gruneberg, P.E. Morris, & R.N. Sykes

(Eds). *Practical Aspects of Memory, Vol. 1: Memory in everyday life* . (pp263-268). Chichester: John Wiley & Sons.

Brewin C., Andrews B. & Gotlib I.(1993) Psychopathology and early experience: A reappraisal of retrospective reports. *Psych ologivcal Bulletin* , Vol 113 (1),82-98.

Brittlebank, A. D.,Scott, J.,Williams, J.M.G.& Ferrier, I.N. (1993) Autobiographical memory in depression; state or trait marker? *British Journal of Psychiatry,* 162, 118-121.

Broadbent, D. E. (1958). *Perception and Communication,* New York Pergamon Press.

Brown, A.L. (1989). Analogical learning and transfer: What develops? In S. Vosniadou & A.Ortony (Eds). Similarity and Analogical reasoning (pp369-412). Cambridge, England, Cambridge University Press.

Brown, J. (1958). Some tests of the decay theory of immediate memory. *Qusrterly Journal of Experimental Psychology,* 10, 12-21.

Brown, R. & Kulik, J. (1977). Flashbulb Memories. *Cognition,* 5, 73-99

Burke, M., & Mathews, A (1992). Autobiographical memory and clinical anxiety. *Cognition and Emotion*, 6, 23-35.

Burgess, P.W. & Shallice. T. (in press). Fractionnement du syndrome frontale. *Revue de N europsychologie.*

Butters, N. & Cermak, L.S. (1986). A.case study of the forgetting in autobiographical knowledge: Implications for the study of retrograde amnesis. In D.C. Rubin (Ed.) *Autobiographical Memory,* pp 253-289. Cambridge. MA: Cambridge University Press.

Cantor, J., & Engle, R.W. (1993). Working memory capacity and as long term memory activation: An individual differences approach. *Journal of Experimental Psychology: Learning, Memory and Cognition,* 7, 212-230.

Cermak, L.S. and O'Connor, M. (1983). The anterograde and retrograde ability of a patient with amnesia due to encephalitis. *Neuropsychologia,* 21, 213-234.

Cimino C., Verfaellie M. ,Bowers D. & Heilman K. (1991). Autobiographical memory: Influenceof right hemisphere damage on emotionality and specificity. *Brain and Cognition* Vol 15 (1) 106-118.

Clark, H.H. (1973). The language as-fixed-effect fallacy: A critique of language statistics in psychological research. *Journal of Verbal Learning and Verbal Behaviour,* 12, 335-359.

Collins, A.M. & Loftus, E.F. (1975). A spreading-activation theory of semantic processing. *Psychological Review,* 82, 407-428.

Collins, A.M. & Quillian, M.R. (1969). Retrieval time from semantic memory. *Journal of Verbal Learning and Verbal Behaviour,* 8, 240-247.

Conrad, R. (1964). Acoustic confusion in immediate memory.*British Jouranl of Psychology,* 55, 75 - 84.

Conway, A. R., & Engle, R.W. (1994). Working memory and retrieval: A resource dependent inhibition model. *Journal of Experimental Psychology: General,* Vol 123, No. (4). 354-373.

Conway, M.A. (1987). Verifying autobiographical facts. *Cognition,* 25, 39-48

Conway, M.A. (1988a).' Images in autobiographical memory'. In Denis,M. , Engelkamp, J. and Richardson, J.T.E., (Eds). *Cognitive and Neuropsychological Approaches to Mental Imagery.* The Hague, Martinus Nijhoff, 337-46.

Conway, M.A. (1990). Associations between autobiographical memories and conceptual knowledge.'*Jouranl of Experimental Psychology: Learning , Memory and Cognition. 16,* 799-812.

Conway,M.A. (1990a) *Autobiographical Memory: An Introduction.* Milton Keynes: Open University Press.

Conway, M.A., and Bekerian, D.B. (1987). Organization in autobiographical memory. *Memory and Cognition,* 15 (2), 119-132.

Conway, M.A. & Rubin, D.C. (1993). The structure of autobiographical memory. In A.E. Collins, S.E. Gathercole, M.A.Conway, & P.E.M. Morris (Eds). *Theories of Memory* (pp103-137). Hillsdale, NJ: Erlbaum.

Conway, A.R.A. & Engle R.W. (1994). Working Memory and Retrieval: A Resource Dependent Inhibition model. *Journal of Experimental Psychology: General,* Vol 123, No.4, 354-373.

Crovitz, H.F., and Schiffman, H. (1974). Frequency of episodic memories as a function of their age. *Bulletin of the Psychonomic Society.,*4,517-18.

Craik, F.I.M. & Lockhart, R.S. (1972). Levels of processing: A framework for memory research. *Journal of Verbal Learning and Verbal Behaviour,* 11, 671-684.

Craig, 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., Anderson, N., Kerr, S.A.,& Li, K.H. (1995). Memory changes in normal ageing. In A.D.Baddeley, B.A.Wilson, & F.N. Watts (Eds). *Handbook of Memory Disorders.* Chichester: John Wiley.

Crowder, R. G. (1993). Systems and principles in memory theory: Another critique of pure memory. In A. F. Collins, S. F. Gathercole, M.A. Conway, & P.E. Morris (Eds). *Theories of Memory* (pp139-161) Hove, Lawrence Erlbaum Associates Limited.

Damasio, A.R., Graff - Radford, N.R., Eslinger, P.J., Damasio, H., & Kessell, N. (1985). Amnesia following basal forebrain lesions. *Archives of Neurology,* 42, 263-271.

Damasio, A. R. (1989). Time locked multiregional retroactivation: A systems level proposal for the neural substrates of recall and recognition. *Cognition,* 33, 25-62.

Daneman, M., & Carpenter, P.A. (1980) Individual differences in working memory and reading. *Journal of Verbal Learning and Verbal Behaviour*, 19, 450-466.

Daneman, M. & Tardiff, T. (1987). Working memory and reading skill re-examined. In Coltheart, M. (Ed). *Attention and Performance X11.* (pp.491-508). Hove : Lawrence Erlbaum Associates.

Della Barba, G., Cipolotti, L., and Denes, G. (1990). Autobiographical memory loss and confabulation in Korsakoff's syndrome: A case report. *Cortex,* 26, 525-534.

Della Sala, S., & Spinnler, H., (1986). " Indifference Amnesique" in a case of global amnesia following acute brain hypoxia. *European Neurology* , 25, 98-109.

Della Salla, S., Pasetti, C., & Sempio, P. (1987). Deficit of the "Primary Effect" om Parkinsonians interpreted by means of the working memory model. *Swiss Archives of Neurology, Neurosurgery and Psychiatry,* 138, 5-14.

Della Sala, S., Laiacona, M., Spinnler, H., and Trivelli. C. (1993). Impaired autobiographical recollection in some frontal patients. *Neuropsychologia,* 31, 823-840.

Della Sala, S., Gray, C., Spinnler, H., and Trivelli C. (in prep). The riddle of executive testing.

De Beni, R., & Pazzaglia, F. (1995). Memory for different kinds of mental images: Role of contextual and autobiographic variables. *Neuropsychologia,* Vol 33, No.11, 1359-1371.

Denis, M. (1991). *Image and Cognition.* Harvester Wheatsheaf

Denis, M. (1983). Valeur d'imagerie et composition semantique: analyse de concepts. *L'anee Psychologique,,* 84, 327-45.

De Renzi, E., Liotti, M., and Nichelli, P. (1987). Semantic amnesia with preservation of autobiographical memory. A case report. *Cortex,* 25, 197-217.

Dewhurst, A.D., & Conway, M.A. (1994). Pictures, images and recollective experience. *Journal of Experimental Psychology: Learning , Memory and Cognition,* Vol 20 (3), 1088-1098.

Dienes,Z. Broadbent,D. & Berry, D (1991). Implicit and explicit knowledge bases in artificial grammar learning. *Journal of Experimental Psychology: Learning, Memory and Cognition*, 17, 857-887.

Dritschel B. (1991) Autobiographical memory in natural discourse. A methodological note. *Applied cognitive Psychology* , Vol5 (4), 319-330.

Dritschel, B. H., Williams, J.M.G., Baddeley, A.D. and Nimmo- Smith, I. (1992). Autobiographical memory fluency: A method for the study of personal memory. *Memory and Cognition,* 20, 133-140.

Dudycha, G.J., & Dudycha, M.M. (1941). *Childhood memories: A review of the literature,,* 38, 668-682.

Duncan, J. (1986). Disorganization of behaviour after frontal lobe damage. *Cognitive Neuropsychology* , 3, 271-290.

Duncan, J. (1993). Selection of input and goal in the control of behaviour. In A. Baddeley & L. Weiskrantz (Eds). *Attention : Selection , Awareness and control.* (pp171-187). Oxford: Clarendon Press.

Duncan, J., Johnson, R., Swales, M., & Freer, C. (in prep). Frontal lobe deficits after head injury: unity and diversity of function.

Eddy, J.K. & Glass, A.L. (1981). Reading and listening to high and low imagery sentences. *Journal of Verbal Learning and Verbal Behaviour,* 20, 333-345.

Ellis, H.C. & Ashbrook, P.W. (1988) Resource allocation model of the effects of depressed mood states on memory. In K. Fiedler & J. Forgas (Eds) *Affect, cognition and social behavior* (pp. 25-43). Toronto,Canada: Hogrefe.

Ellis, N.C. (1991). Word meaning and the links between the verbal system and modalities of perception and imagery. In R.H.Logie, & M.Denis (Eds).*Mental Images in Human Cognition.*, Elsevier Science Publications.

Engle, R.W., Cantor, J., & Carullo, J.J. (1992). Individual differences in working memory and comprehension: A test of four hypotheses. *Journal of Experimental Psycjology: Learning , Memory and Cognition,* 18, 972-992.

Engle, R.W., Nations, J.K., & Cantor, J. (1990). Is working memory just another name for word knowledge? *Journal of Educational Psychology,* 82, ,799-804.

Engle, R.W. (in press). Working Memory and retrieval: An inhibition - resource approach. In J.T.E. Richardson (Ed), *Working Memory in human cognition.*, New York, Oxford University Press.

Evans, J., Williams, J.M.G., O'Loughlin, S. & Howells, K. (1992) Autobiographical memory and problem-solving strategies of parasuicide patients. *Psychological Medicine,* 22, 399 - 405.

Evans, F. E. (1978) Monitoring attention deployment by random number generation: an index to measure subjective randomness. *Bulletin of the Psychonomic Society,* Vol 12 (11), 35-38.

Farrar, M. J., & Goodman, G.S., (1990). Developmental differences in the relation between scripts and episodic memory.

Fawcett, J., Scheftner, W.A. Fogg, L., Clark, D.C., Young, M.A., Hedeker, D. & Gibbons, R. (1990). Time-related predictors of suicide in major affective disorder. *American Journal of Psychiatry,* 147, 1189-1194.

Fitzgerald, J.M. (1988) Vivid memories and the reminiscence phenomenon: The role of a self-narrative. *Human Development,,* 31, 261-270

Fivush, R., Hudson, J. and Nelson, K. (1984). Children's long term memory for a novel event: an exploratory study. *Merrill- Palmer Quarterly,* **30**, 303-316.

Fivush, R., Kuebli, J., and Clubb, P. (1992). The structure of events andevent representations: a developmental analysis. *Child Development,* **63**, 188- 201.

Fivush, R. & Reese, E. (1991). Parental styles for talking about the past. Paper presented at the International Conference on Memory. Lancaster, UK.

Fodor, J.A., & Pylyahyn, Z.W. (1988). Connectionism and cognitive architecture: A critical analysis, *Cognition*, 28, 3-71.

Freidman W. (1993). Memory for the time of past events. *Psych ological Bulletin* Vol 113 (1) 44-66

French, L.A. and Nelson, K. (1982). Taking away the supportive context: Preschoolers talk about the 'then and there'. *Quarterly Newsletter of the Laboratory of Comparative Human Cognition*, 4, 1-6.

Galton, F. (1883). *Inquiries into Human Faculty and its Development*. London, Macmillan, 1st edition.

Gathercole, S., & Baddeley, A.D. (1989). Evaluation of the role of phonological STM in the development of vocabulary in children: A longitudinal study. *Journal of Memory and Language*, 28, 200-213.

Gathercole, S., & Baddeley, A.D. (1990). The role of phonological memory in vocabulary acquisition: A study of young children learning arbitrary names of toys. *British Journal of Psychology*, 81, 439-454.

Gathercole, S., & Baddeley, A.D. (1994). *Working Memory and Language*. Hove, Lawrence Erlbaum Associates Ltd.

Gilhooly, K.J., Logie, R.H., Wetherick, N.E., & Wynn. V. (1993). Working memory and strategies in syllogistic reasoning tasks, *Memory and Cognition*, 21, 115-124.

Glanzer, M., & Cunitz, A.R. (1966). Two storage mechanisms in free recall. *Journal of Verbal Learning and Verbal Behaviour*, 5, 351-360.

Glass, A.L., Eddy, J.K. & Schwanenflugel, J. (1980). The verification of high and low imagery sentences. *Journal of Experimental Psychology: Human Learning and Memory*, 6, 692-704.

Green,R.A. & Schanks,D.R. (1993) On the existence of independent explicit and implicit learning systems: An examination of some evidence. *Memory and Cognition* , 21, 304-317.

Greene, J.D.W., Hodges, J.R. and Baddeley, A.D. (1995). Autobiographical Memory and Executive Function in early dementia of Alzeimer Type. *Neuropsychologia,* Vol.33, No. 12, 1647- 1670.

Groot, A.M.B. (1989). Representational aspects of word imageability and word frequency as assessed through word association. *Journal of Experimental Psychology: Learning , Memory and Cognition,* 15, No.5, 824-845.

Hammond, N.R., & Fivush, R. (1991). Memories of Mickey Mouse: Young children recount their trip to Disneyworld. Cognitive Development, 6, 433-448.

Hasher, L,. & Zachs, R.T. (1988). Working memory, comprehension and ageing: A review and a new view. In G.H. Bower (Ed) *The psychology of learning and motivation,* Vol 22 (pp193- 225) New York Academic Press.

Heim, A. (1975). AH2 and AH3. Windsor Berkshire. AFER Publishing

Hertel, P.T. & Hardin, T.S. (1990) Remembering with and without awareness in a depressed mood: evidence of deficits in initiative. *Journal of Experimental Psychology*: General, 119, 45 - 59

Hertel, P.T., & Rude, S.S. (1991). Depressive deficits in memory: Focusing attention improves subsequent recall. *Journal of Experimental Psychology: General,* Sep Vol 120 (3), 301-309.

Hitch, G.J (1980). Developing the concept of working memory. In G. Claxton (Ed) *Cognitive Psychology: New Directions* (pp 1554-196). London: Routledge & Kegan Paul.

Holland, C.A. and Rabbitt, P.M.A. (1991). Ageing Memory: Use versus impairment. *British Journal of Psychology,* 82, 29-38.

Holland, C.A. and Rabbitt, P.M.A. (1990). Autobiographical and text recall in the elderly: An investigation of a processing deficit. *The Quarterly Journal of Experimental Psychology.* 42A, 441-470.

Horne, R.L., Evans, F.J.,& Orne, M.T., (1982). Random number generation: psychopathology and therapeutic change. *Archives of General Psychiatry,* Vol 39 (6), 680-683.

Hudson, J. & Nelson, K. (1986). Repeated encounters of a similar kind: Effects of familiarity on children's autobiographic memory. *Cognitive Development,* 1, 253-271

Hudson, J. A. (1990). Constuctive processes in children's event memory. *Developmental Psycho;logy* 2, 180-187.

Hudson, J.A., & Shapiro, L., (1991). Effects of task and topic on children's narratives. In A Mc Cabe & C. Peterson (Eds). *New directions in developing narrative structure* (pp.89-136). Hillsdale, NJ: Lawrence Erlbaum Associates.

Hulme, C., Maughan, S. & Brown, G.D.A. (1991). Memory for familiar and unfamiliar words: Evidence for a long term memory contribution to short term memory span. *Journal of Memory and Language,* 30, 685-701

Ikegami, T. (1986). The role of affect in person memory. The influence of positive and negative affeact upon recognition memory. *Japanese Psychological Research ,* Vol 28 (3), 154-159.

Intons-Peterson. M.J. (1992). Components of auditory imagery. In *Auditory Imagery,* (Ed) Daniel Reisberg. Hillsdale, N. J. Lawrence Erlbaum Associates.

Isen, A.M. (1984). Towards understanding the role of affect in cognition. In Wyer, R. & Srull, T. (Eds). *Handbook of Social Cognition.* pp179-236. Hillsdale, N.J.: Lawrence Erlabaum Associates.

Isen, A.M. (1987). Positive affect, cognitive processes and social behaviour. In L. Berkowitiz (Ed) *Advances in experimental social psychology ,* (Vol 20, pp203-253). New York: Academic Press.

Isen, A.M., Daubman, K.A., & Norwicki, G.P. (1987). Positive affect facilitates creative problem solving. *Journal of Personality and Social Psychology*, *52*, 1122-1131.

Isen, A.M., Shalker, T., Clark, M., & Karp, L. (1978). Affect, accessibility of material in memory and behaviour: A cognitive loop? *Journal of Personality and Social Psychology, 36,* 1-12.

James, W. (1890). *Principles of Psychology, Vol. 1.* (1905 ed.). London: Methuen & Co.

John, C.H. (1988). Emotionality ratings and free association norms of 240 emotional and non-emotional words. *Cognition and Emotion,* 2, 49-70.

Johnson, M.K.,Foley, M.A., Suengas, A.G., & Raye, C.L. (1988). Phenomenal characteristics of memories for perceived and imagined autobiographical events. *Journal of Experimental Psychology: General*, 117, 371-376.

Johnson, M. K. & Hirst W. (1993) MEM: Memory subsystems as processes. In A.F.Collins, S.E.Gathercole M.A.Conway, and P.E.Morris. (Eds).*Theories of memory.*, Lawrence Erlbaum Associates .

Johnson, M.K., Hashtroudi, S., & Lindsay D.S. (1993). Source Monitoring. *Psychological Bulletin*,,Vol.114, No.1. 3- 28

Jones, G.V. (1985). Deep dyslexia, imageability and ease of predication. *Brain and Language,* 24, 1-19.

Jones, G.V. (1988). Images, predicates and retrieval cues. In M.Denis, J.Englekamp, & J.T.E. Richardson (Eds). *Cognitive and nuropsychological approaches to mental imagery.* Amsterdam, Martinus Nijhoff, B.V.

Just, M. & Carpenter, P. (1992). A capacity theory of comprehension: Individual differences in working memory. *Psychological Review,* 99, 122-149.

Kahneman, D. & Tversky, A. (1972). Subjective probability: A judgement of representativness. *Cognitive Psychology,* 3, 430-454.

Kieras, D. (1978). Beyond pictures and words: Alternative information-processing models for imagery effects in verbal memory. *Psychological Bulletin,* 85, 532-554.

Kintsch, W. (1980). Semantic memory : A tutorial. In R.S. Nickerson (Ed.) *Attention and Performance V111,* (pp.595-620). Hillsdale, N.J.: Lawrence Erlbaum Associates Inc.

Kintsch, W. & VAn Dijk, T. A. (1978). Towards a model of text comprehension and production. Psychological Review, Vol 85, (5), 363-394.

Kolodner, J.L., (1983). Maintaining memory organization in dynamic long term memory. *Cognitive Science,* 7 243-80.

Kopelman M.D. Wilson B.A. Baddeley A. (1989). The autobiographical memory interview: A new assessment of autobiographical and personal semantic memory in amnesic patients.*Journal of Cinical and Experimental neurology.* Vol 11(5) 724-744.

Kopelman, M.D. (1992). Autobiographical memory in clinical research and practice. In M.A. Conway,D.C.Rubin, H.Spinnler &W.A.Wagenaar (Eds). *Theoretical perspectives on autobiographical on autobiographical memory* (pp427-450). Dordrecht, The Netherlands: Kluwer Academic Publishers.

Kopelman,M.D., Guinan, E.M. and Lewis, P.D.R. (1994). Delusional Memory, confabulation, and frontal lobe function. In Campbell, R. and Conway, M. (Eds), *Broken Memories.* Oxford: Blackwell Publishers.

Kosslyn, S. M. (1980). *Image and Mind,* Cambridge, MA: Havard University Press.

Kosslyn, S. M. (1987). Seeing and imagining in the cerebral hemispheres: a computational approach. *Psychological Review, ,94,* 148-175.

Kosslyn, S. M. (1994). *Image and Brain: The Resolution of the Imagery Debate,* Mit Press, Cambridge,Mass

Kosslyn, S.M. (1995). Two types of image generation: Evidence for left and right hemispheric processes. *Neuropsychologia,* Vol 33, N0.11, pp1485-1510.

Kuyken, W. (1992). The beliefs, coping strategies and early experiences of depressed patients. Unpublished doctoral thesis.

Kuyken, W., & Brewin, C.R. (1994). Intrusive memories of childhood abuse during depressive episodes. *Behaviour Research and Therapy ,* Vol 32 (5), 525-528.

Kuyken, W., & Brewin, C. R. (1995). Autobiographical memory functioning in depression and reports of early abuse. *Journal of Abnormal Psychology,* Nov. Vol 104 (4), 585-591.

Kuyken, W., & Dagleish, T. (1995). Autobiographical memory and depresssion. *British Journal of Clinical Psychology,.* Vol 34 (1), 89-92.

Kyllonen, P.C., & Christal, R.E. (1990). Reasoning ability is (little more) than working memory capacity. *Intelligence,* 14, 389-433.

Larsen. S. F. (1992). Personal context in autobiographical and narrative memories. In M.A. Conway, D.C.Rubin, H. Spinnler and W.A.Wagenaar (eds), *Theoretical Perspectives on Autobiographical Memory.* Dordrecht, Boston & London, Kluwer Academic Publishers

Lehto, J. (1996). Are executive function tests dependent on working memory capacity? *The Quarterly Journal of Experimental Psychology,* 46A, (1), 29-50.

Leichtman, M.D., & Ceci, S.J. (1995). The effects of stereotypes and suggestions on preschoolers reports. *Developmental Psychology,* 31 (4), 568-578.

Levin, H.S., Culhane, K.A., Hartmann, J., Evankovitch, K., Mattson, A.J., Harward, H., Ringholz, G., Ewing-Codds, L., & Fletcher, J.M. (1991). Developmental changes in performance on tests of purported frontal lobe functioning. *Developmental Neuropsychology,* 7, 377-395.

Levy, B.A. (1971). The role of articulation in auditory and visual short term memory. *Journal of Verbal Learning and Verbal Behaviour,* 10, 123-132.

Linton, M. (1978). Real world memory after six years: an in vivo study of very long term memory. In Gruneberg, M.M., Morris, P.E., and Sykes, R.N., (Eds). *Practical Aspects of Memory* .,(pp69-76). London, Academic Press.

Linton, M. (1982). Transformations of memory in everyday life. In U. Neisser (ed), *Memory Observed* (pp79-89). San Francisco: W.H. Freeman.

Linton, M. (1986). Ways of searching and the contents of memory. In Rubin, D.C. (Ed). *Autobiographical Memory.* Cambridge, Cambridge University Press.

Logie, R.H. (1995). *Visuo- spatial working memory.* Hove: Lawrence Erlbaum Ltd.

Lopes, L.L. & Oden, G.C. (1987). Distinguishing between random and non random events. *Journal of Experimental Psychology: Learning Memory and Cognition*, Vol 13, No. 3, 392-420

Lucariello, J., & Nelson, K. (1985). Slot-filler categories as memory organizers for young children. *Developmental Psychology,* 21, 272-282.

Lucariello, J. and Rifkin, A. (1986). ' Event knowledge as the basis for categorical knowledge'. In K.Nelson (ed). *Event Knowledge: Structure and function in development,* (pp189-203). Hillsdale, NJ: Erlbaum.

Macleod, A. K. & Williams, J. M. G., & Linehan, M. M. (1992). New developments in the understanding and treatment of suicidal behaviour. *Behavioural Psychotherapy,* 20, 193-218.

Mandler, J. M., (1979) ' Categorical and schematic organization in memory'. In C.R. Puff (ed) *Memory Organization and Structure* (pp259-299). New York: Academic Press.

Marsaglia, G., Zaman, A., & Tsang, W.W. (1990). Toward a universal random number generator. *Statistics and Probability Letters,* 8, 35- 39.

Marschark, M,. & Hunt, R.R. (1989). A reexamination of the role of imagery in learning and memory. *Journal of Experimental Psychology: Learning , Memory and Cognition,* 15, 710-720.

Martin, M. (1978). Memory span as a measure of individual diffferences in memory capacity. *Memory & Cognition,* 6, 194-198.

Martin, M. (1985). Neuroticism or predispositon towards depression: a cognitive mechanism. *Personality and Individual Differences,* 6, 353-365.

Minsky,M.L. (1975). A framework for representing knowledge. In P.H. Winston (Ed.), *The Psychology of Computer Vision,* (pp.211-277). New York: McGraw Hill.

McCarthy,R.A. & Warrington,E.K. (1990) *Cognitive Neuropsycholgy. A Clinical Introduction.* Academic Press, San Diego.

Mc Nally. R., Litz, B.T., Prassas, A., Shin, L.M. & Weathers, F.W. (1994). Emotional priming of autobiographical memory in post- traumatic stress disorder. *Cognition and Emotion,* 8, 351-367.

Moore, R.G., Watts, F.N. & Williams, J.M.G. (1988). The specificity of personal memories in depression. *British Journal of Clinical Psychology,,* 27, 275-276.

Morton, J. (1967). A singular lack of incidental learning. *Nature,* 215, 203-204

Morton, J. (1990). The development of event memory. *The Psychologist* ,Bulletin of the British Psychological Society.

Morton, J., Hammersley, R.H., & Bekerian, D.A. (1985). Headed Records: a model for a memory and its failures. *Cognition,* 20, 1-23.

Murray, D. (1968). Articulation and acoustic confusability in short term memory. *Journal of Experimental Psychology,* 78, 679-684.

Navon, D., and Gopher, D (1980). How is performance limited: Testing the notion of central capacity. *Acta Psychologica,* Vol 46 (3), 161-180

Neisser, U. (1982). *Memory Observed.* San Francisco: Freeman

Nelson, K,. & Grundel, J. (1981). Generalized event representations: Basic building blocks of cognitive development. In M. Lamb & A. Brown (Eds), *Advances in developmental psychology* (vol.1) Hillsdale, NJ: Lawrence Erlbaum Associates.

Nelson, K. (1986) *Event knowledge: Structure and function in development.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Nelson K.(1992) Emergence of autobiographical memory at age 4. *Human Development* ,Vol 35 (3) 172-177

Nelson K. (1993) Explaining the emergence of autobiographical memory in early childhood. In A.F.Collins, S.E.Gathercole M.A.Conway, and P.E.Morris. (Eds).*Theories of memory.* Lawrence Erlbaum Associates.

Neuringer, A. (1986). Can people behave 'randomly?'.The role of feedback. *Journal of Experimental Psychology: General,* 15, 62-75.

Nezu, A.M., & Carnevale, G.J. (1987). Interpersonal problem solving and coping reactions of Vietnam veterans with postraumatic stress disorder. *Journal of Abnormal Psychology, 96,* 155-157.

Nickerson, R.S. & Adams, M.J. (1979). Long term memory for a common object. *Cognitive Psychology,* 11, 287- 307.

Noble, C.E. (1952). An analysis of meaning. *Psychological Review,* 59, 421-430.

Norman,D.A. & Bobrow, D.G.(1979) Descriptions: an intermediate stage in memory retrieval. *Cognitive Psychology,* 11, 107-123.

Norman,D.A. & Shallice,T. (1980). Attention to action: Willed and automatic control of behaviour. University of California San Diego, CHIP Report 99.

Oaksford, M., Morris, F., Williams, J.M.G. & Grainger, B. (1996). Mood reasoning and executive processes. *Journal of Experimental Psychology: Learning , Memory and Cognition, Vol 22,* (2) 477-493.

O'Connell, B. and Gerard, A., (1985). 'Scripts and scraps : The development of sequential understanding'. *Child Development*, 56, 671-81.

Ogden, J. A. (1993). Visual object agnosia, prosopagnosia, achromotopsia, loss of visual imagery, and autobiographical memory following recovery from cortical blindness: Case M.H. *Neuropsychologia*, 31, 571-589.

Paivio, A., Yuille, J.C. & Madigan, S.A. (1968) Concreteness, imagery and meaningfulness values for 925 nouns. *Journal of Experimental Psychology , Monograph Supplement*, 76, 1 - 25.

Paivio, A., (1971) *Imagery and verbal processes.* New York; Holt, Rinehart, and Winston. (Reprinted 1979) Hillsdale, N.J. : Erlbaum.

Paivio, A., (1972) Symbolic and sensory modalities of memory. In *Third Western Symposium on learning : Cognitive Learning.* M.E., ed. Bellingham: Western Washington State College.

Paivio, A., (1986) *Mental Representations: A dual coding approach.* New York: Oxford University Press.

Perner, J. (1991). *Understanding the representational mind..* Cambridge, MA: MIT Press.

Peterson, L.R., & Peterson, M.J., (1959). Short term retention of individual verbal items. *Jouranl of Experimental Psychology,* 58, 193-198.

Petrie, K,. Chamberlain, K, & Clarke, D. (1988). Psychological predictors of future suicidal behaviour in hospitalized suicide attempters. *British Journal of Clinical Psychology*, 27, 247-258

Picariello, M.L., and Pillemer, D.B., (1991). Preschooler's memory for specific instances of routine events. Paper presented at the meetings of the Society for Research in Child Development, Seattle, (April)

Pillemer, D., & White, S.H., (1989). Childhood events recalled by adults and children. In H.W. Reese (Ed). *Advances in child development and behaviour:* Vol.22 (pp.297- 346). New York: Academic Press.

Price, D.W.W. and Goodman, G.S. (1990). Visiting the wizard; children's memory for a recurring event. *Child Development*,, 61, 664- 428

Puffet, A., Jehin-Marchot, D., Timsit-Berthier, M., & Timsit, M. (1991). Autobiographical memory and major depressive states. *European Psychiatry*, 6, 89-137.

Pylyshyn, Z. W. (1981). The imagery debate: Analogue media versus tacit knowledge. *Psychological Review*, 88, 16-45.

Quillian, M.R. (1969). The teachable language comprehender : A simulation program and theory of language. *Communication of the ACM*, 12, 459-476.

Rabbitt, P. M. A. (1983). How can we tell whether human performance is related to chronological age? In D. Samuel, B. Megeu, S. Gershon, V.E.Grimm, and S. Teffrano (Eds). *Aging of the Brain*, (pp 9-18). New York Raven Press.

Rabbit, P. & Winthorpe, C. (1987). What do old people remember?. The Galton paradigm reconsidered. *In Pratical Aspects of Memory: Current Research and Issues.* (Eds) Gruneberg, M.M., Morris, P. E., & Sykes, R.N. Wiley & Sons.

Raajmakers, J.G., & Shiffrin, R.M. (1981). Search of associative memory. *Psychological Review*, 88, 93-134.

Rath, G.J. (1966). Randomization by humans. *American Journal of Psychology*, 79, 97-103.

Reiser, B.J., Black, J. B. & Abelson, R.P. (1985) Knowledge structures in the organisation and retrieval of autobiographical memories.*Cognitive Psychology*, 17, 89-137.

Reiser, B.J. (1986). The encoding and retrieval of memories of real world experiences. In J.A. Galambos, R.P. Abelson, and J.B. Black (eds), *Knowledge Structures* (pp71-99).Hillsdale, NJ; Erlbaum.

Reiser, B.J., Black, J.B., and Kalamarides, P. (1986). Strategic search processes. In D.C. Rubin (ed). *Autobiographical Memory* (pp100-121). New York: Cambridge University Press.

Richards, A., &Whittaker, T.M. (1990). Effects of anxiety and mood manipulation in autobiographical memory. *British Journal of Clinical Psychology*, 29, 145-154.

Richardson, J.T.E., & Baddeley, A.D. (1975). The effect of articulatory suppression in free recall. *Journal of Verbal Learning and Verbal Behaviour*, 14, 623-629.

Richardson, J.T.E. & Barry, C. (1985). The effects of minor closed head injury upon human memory: Further evidence for the role of mental imagery. *Cognitive Neuropsychology*, 2, 149-168.

Robinson, J. A. (1976). Sampling autobiographical memory. *Cognitive Psychology*, 8, 578-595.

Robinson, J. (1986b). Temporal reference systems and autobiographical memory. In Rubin, D.C. (Ed), *Autobiographical Memory* Cambridge, Cambridge University Press.

Robinson, J., and Swanson, K. (1990). Autobiographical memory: The next phase. Special Issue. Applying cognitive psychology in the 1990's. *Applied cognitive Psychology* , Vol 4 (4) 321-325.

Rosenberg, S. Weber, N. Crocq, M. A. Duval,F. & Macher, J.P. (1990). Random number generation by normal, alcoholic and schizophrenic subjects. *Psychological Medicine*, ,20, 953-960.

Ross, B.H. (1984). Remindings and their effects in learning a cognitive skill. *Cognitive Psychology, 16,* 371-416.

Rubin, D.C., and Kozin, M. (1984). Vivid Memories.*Cognition* , 16, 81-95.

Rubin, D.C. (1986). *Autobiographical Memory*. Cambridge: Cambridge University Press.

Rubin, D.C. & Kozin, M. (1984). Vivid memories. *Cognition*,, 16, 81-95.

Rubin, D.C., Wetzler, S.E., and Nebes, R.D. (1986). Autobiographical facts across the lifespan, In Rubin, D.C. (Ed). *Autobiographical Memory* . (pp.202-21).Cambridge, Cambridge University Press.

Rundus, D. (1971). Analysis of rehearsal processes in free recall. *Journal of Experimental Psychology,* 89, 63-77.

Rumelhart, D.E., & McClelland, J.L. (1986). *Parallel distributed processing: Explorations in the microstructures of c ognition Vol.1: Foundations.* Cambridge, Mass: M.I.T. Press.

Ryle, G (1949). *The Concept o f Mind*_London: Hutchinson.

Salaman, E. (1970). *A Collection of Moments: A Study of Involuntary Memories.* London, Longman.

Salter, D. & Platt, S. (1990). Suicidal intent, hopelessness and depression in a parasuicide population: The influence of social desirability and elapsed time. *British Journal of Clinical Psychology,* 29, 361-171.

Salthouse, T.A., Mitchell, D.R.D., Skovronek, E., & Babock, R.L. (1989). Effects of adult age and working memory on reasoning and spatial abilities. *Journal of Experimental Psychology: Learning , Memory and Cognition,* 15, 507-516.

Salthouse, T.A. (1991). Learning and memory: Progress and challenge. In D.E. Meyer & S. Kornblum (Eds). Attention and Performance X1V: Synergies in experimental psychology, artificial intelligence and cognitive neuroscience, (pp509-528). Cambridge MA: MIT Press.

Schank, R.C., & Abelson, R.P. (1977). *Scripts, Plans, Goals and Understanding.* Hillsdale, NJ: Erlsbaum

Schank, R. (1982). *Dynamic Memory: a theory of reminding and learning in computers and people.* New York: Cambridge University Press.

Schooler,J.W.,& Hermann, D.J. (1992). There is more to episodic memory than just episodes. In M.A. Conway, D.C.Rubin, H. Spinnler and

W.A.Wagenaar (eds), *Theoretical Perspectives on Autobiographical Memory.* Dordrecht, Boston & London, Kluwer Academic Publishers.

Schwanenflugel, P.J., & Shobem, E.J. (1983). Differential concrete effects in the comprehension of abstract and concrete verbal materials. *Journal of Experimental Psychology: Learning, Memory and Cognition,* 9, 82-102.

Schwartz, E. L. (1984). Anatomical and physiological correlates of visual computation from striate to infero-temporal cortex. *IEEE, Transactions and Systems. Manual of Cybnetics.* SMC-14, 257-271.

Scoville, W. B., & Milner, B. (1957). Loss of recent memory after bilateral hippocampal lesions. *Journal of Neurology, Neurosurgery and Psychiatry,* 20, 11-21.

Shallice, T., & Warrington, E.K. (1970). Independent functioning of verbal memory stores: A neuropsychological study. *Quarterly Journal of Experimental Psychology,* 22, 261-273

Shallice,T. (1988). *From Neuropsychology to Mental Structure..* Cambridge University Press,Cambridge.

Shallice, T. & Burgess, P.W. (1991). Deficits in strategy application following frontal lobe damage in man. *Brain* (114), 727-741.

Shallice, T. & Burgess, P.W. (1993). Supervisory control of action and thought selection. In A. Baddeley, & L. Weiskrantz (Eds). *Attention , Selection, Awarenesss and Control.* (pp171-187). Oxford OUP.

Shute, V. J. (1991). Who is likely to acquire programming skills? *Journal of Educational Computing Research,* 7,1-24.

Singer, J. A., & Moffitt, K.H. (1992). An experimental investigation of specificity and generality in memory narratives. *Imagination, Cognition, and Personality,* Vol 11 (3), 233-257.

Skinner, B.F. (1942). The processes involved in the repeated guessing of alternatives. *Journal of Experimental Psychology,* 30, 495- 503.

Slovic, P., Kunreuther, H. & White, G.F. (1974). Decision processes, rationality, and judgement of natural hazards. In White, G.F. (Ed). *National Hazards, local national and global.* London Open University Press.

Spatt. J. & Goldenberg, G. (1993). Components of random generation by normal subjects and patients with dysexecutive syndrome. *Brain and Cognition,* 23, 231- 242.

Spinnler, H., & Della Salla, S. (1988). The role of clinical neuropsychology in the neurological diagnosis of Alzheimer's disease. *Journal of Neurology,* 235, 258-271.

Sternberg, S. (1966). High-speed scanning in human memory. *Science,* 153, 652-654.

Stuss, D.T., and Benson, D.F. (1986). *The Frontal Lobes.* Raven Press, New York.

Teasdale,J.D. Dritschel,B.H. Taylor, M.J. Proctor,L. Lloyd, C.A. Nimmo-Smith, I. & Baddeley, A.D. (1995) . Stimulus independent thought depends on central executive resources. *Memory & Cognition* , 23 (5) 551-559

Tessler, M. (1986). Mother-child talk in a museum: The socialization of a memory. New York: City University of New York Graduate Centre.

Teuber, H. L., Milner, B., & Vaughan, H.G., (1968). Persistent antergrade amnesia following a stab wound in the basal brain. *Neuropsychologia,* 6, 267- 282.

Todd, C.M. (1986). Long term recall of everyday events by preschool children. In J. Hudson (Chair), Learning to talk about the past. Symposium conducted at the Southeastern Conference on Human Development, Nashville, (April).

Tulving, E.S. (1966). Subjective organization in free recall of "unrelated" words. *Psychological Review,* 69, 344-354.

Tulving, E.S. (1972) Episodic and semantic memory. In E. Tulving & W. Donaldson (Eds.) *Organization of memory*, (pp.382-403). New York: Academic Press.

Tulving, E.S. (1983). *Elements of Episodic Memory.* Oxford. OUP.

Tulving, E., & Thompson, D.M. (1973). Encoding specificity and retrieval processes in episodic memory. *Psychological Review,* 80, 353-373.

Turner, M.L., & Engle, R.W. (1989). Is working memory capacity task dependet? *Journal of Memory and Language,* 28, 127-154.

Tune, G. S. (1964a). Response preferences: A review of some relevant literature. *Psychological Bulletin,* 61, 286-302.

Tune, G.S. (1964b). A brief survey of the variables that influence random generation. *Perceptual ans Motor Skills,,* 18, 705-710.

Tverskey, A., & Kahneman, D. (1971). The belief in the law of small numbers. *Psychological Bulletin,* 33, 233-242.

Tzeng, O. J. L. (1973). Positive recency effects in delayed free recall. *Journal of Verbal Learning and Verbal Behaviour*, 12, 436-439.

Ungerer, J.A., (1985). The development of script knowledge in children from 18 to 30 months of age. Paper presented at the Society for Research in Child Development, Toronto, April.

Van der Linden, M., Coyette, F., & Seron, X. (1992). Selective impairment of the "central executive" component of working memory: A single case study. *Cognitive Neuropsychology* 9, 301-326.

von Mises, R. (1957). *Probability statistics and truth.* . Gellringer, H. (Ed and trans). New York, Macmillan. Originally published 1928.

Wagenaar, W. A. (1970b) Subjective randomness and the capacity to generate information. *Acta Psychologia,* 35, 78-87.

Wagenaar, W. A. (1972a). Generation of random sequences by human subjects: A critical survey of literature. *Psychological Bulletin,,77*, 65-72.

Wagenaar, W. A. (1972b). Sequential response bias: A study of choice and chan ce. Unpublished doctoral disseration. Leiden University.

Wagenaar, W.A. (1986). My memory: a study of autobiographical memory over six years. *Cognitive Psychology,* 18, 225-52.

Wagenaar, W.A. (1988). People and places in my memory: A study of cue specificity and retrieval from autobiographical memory. In M.M.Gruneberg, P.E. Morris, & R.N . Sykes, *Practical Aspects of Memory: Crrent Research and Issues* (pp. 295 - 301) Chichester, John Wiley & Sons.

Wahler,R.G. & Afton, A.D. (1980). Attentional processes in insular and non insular mothers: Some differences in their summary reports about child problem behaviours. *Child Behaviour Therapy,* 2, 25-41.

Warrington, E.K., & Shallice, T. (1969). The selective impairment of auditory short term memory. *Brain,,* 92, 885-896

Waters, G.S., & Caplan, D. (1996). Measurement of verbal working memory capacity and its relation to reading comprehension. *Quarterly Journal of Experimental Psychology* , (49A), (1) 51-79.

Watkins, M.J. & Kerkar, S.P. (1985). Recall of a twice presented item without recall of either presentation: Generic memory for events. *Journal of Memory & Language,* , 24, 666-678.

Watkins, M.J., & Peynircioglu, Z.F. (1983). Three recency effects at the same time. *Journal of Verbal Learning and Verbal Behaviour*, 22, 375-384.

Watts, F.N. & Sharrock, R. (1987). Cued recall in depression. *British Journal of Clinical Psychology,* 26, 149-150.

Watts, F. N., & Cooper, Z., (1989). The effects of depression on structural aspects of the recall of prose. *Journal of Abnormal Psychology,* Vol. 98, No.2. 150-153.

Wattenmaker, W.D. & Shoben, E.J. (1987). Context and recallibility of concrete and abstract sentences.*Journal of Experimental Psychology: Learning, Memory and Cognition,* 13, 140-150.

Weiss, R. L. (1964). On producing random responses. *Psychonomic Resports,* 14, 931- 941.

Welsh, M.C., Pennington, B.F., & Groisser, D.B. (1991). A normative developmental study of executive function: A window on prefrontal function in children. *Developmental Neuropsychology* 7, 131- 149.

Wetzel, R.D., Margulies, T., DAvis, R., &Karam, E. (1980). Hopelessness, depression and suicidal intent. *Journal of Clinical Psychiatry,* 49, 159-160.

Whitten, W. B., & Leonard, J.M. (1987). Directed search through autobiographical memory. *Memory and Cognition,* Vol 9 (6) 566-579.

Wike, E.L., & Church, J.D. (1976). Comments on Clark's " The language as fixed-effect- fallacy" *Journal of Verbal Learning and Verbal Behsviour,* 15, 249-255.

Williams, D.M. (1978). The process of retrieval from very long term memory.*Tech. Report,* 75, La Jolla, Calif. University of California, San Diego.

Williams,D.M. &Hollan,J.D. (1981). The processs of retrieval from very long-term memory.*Cognitive Science,* 5, 87-119.

Williams, J.M.G.(1988) General and specific autobiographical memory and emotional disorders. In M.M.Gruneberg, P.E. Morris, & R.N . Sykes, *Practical Aspects of Memory: Crrent Research and Issues* (pp. 295 - 301) Chichester, John Wiley & Sons.

Williams, J.M.G. (1996) The specificity of autobiographical memory in depression. In D. Rubin (Ed) *Remembering our past: studies in autobiographical memory*.. Cambridge, Cambridge University Press.

Williams, J.M.G. & Broadbent, K. (1986) Autobiographical Memory in suicide attempters. *Journal of Abnormal Psychology,* 95, 144 - 9.

Williams, J.M.G. & Dritschel, B. (1988). Emotional disturbance and the specificity of autobiographical memory. *Cognition and Emotion,*, 2, 221 - 34.

Williams, J.M.G. & Dritschel, B.H. (1992) Categoric and extended autobiographical memories. In M.A. Conway, D.C.Rubin, H. Spinnler and W.A.Wagenaar (eds), *Theoretical Perspectives on Autobiographical Memory.* Dordrecht, Boston & London, Kluwer Academic Publishers (pp391-412).

Williams, J.M.G., Ellis, N.C., Tyers, C., Healy, H., Rose, G. & MacLeod, A.K. (1996) The specificity of autobiographical memory and imageability of the future. *Memory & Cognition,* .24 (1) 116-125.

Williams, J.M G., & Dritschel B. (1988). Emotional disturbance and the specificity of autobiographical memory. Special issue. Information processing and the emotional disorders. *Cognition and Emotion* ,1988 Vol 2(3) 221-234

Williams,J.M.G., & Pollock, L.R. (1993). Factors mediating suicidal behaviour: Implications for primary and secondary prevention. *Journal of Mental Health.,* 2, 3-26.

Williams, J.M.G. & Scott, J. (1988). Autobiographical memories in depression. *Psychological Medicine,* 18, 689-695.

Wilkinson, J. (1988b) Preschooler's event memory: Methods facilitating recall. PhD thesis. University College London.

Wilson, B., & Baddeley, A.D. (1988). Frontal lobe amnesia and the dysexecutive syndrome. *Brain & Cognition,*, 7, 712-2320

Wilson, R.S., Bacon, L.D., Fox, J.H., & Kaszniak, A.W. (1983). Primary and secondary memory in dementia of the Alzheimer's type. *Journal of Clinical Neuropsychology,* 5, 334-377.

Winer, B. (1971). *Statistical principles in experimental design* . New York: Mc Graw-Hill.

Winthorpe ,C. & Rabbitt, P.A. (1988) Working memory capacity, IQ, age, and the ability to recount autobiographical events. in M.M.Gruneberg, P.E.Morris & R.N.Sykes (eds) *Practical Aspects of Memory: Current Research and Issues II* (pp 175-179). Chichester :John Wiley & Sons.

Zola-Morgan, S., Squire, L.R., &Ammarel, D.G. (1986). Human amnesia and the medial-temporal region: Enduring memory impairment following a bilateral lesion limited to field CA1 of the hippocampus. *Journal of Neuroscience*, 6, 2950-2967.

Chapter 4

Experiment 1

Table 4.2. Analysis of variance on the specificity of memories retrieved in response to cues varying in frequency and imageability, (subject analysis)
Within subject factors: imageability and frequency.

Source	df	Sum of Squares	Mean Square	F-Value	P-Value	G-G	H-F
Subject	23	435.740	18.945				
Frequency	1	7.594	7.594	.862	.3629	.3629	.3629
Frequency * Sub...	23	202.656	8.811				
Imageability	1	429.260	429.260	44.676	.0001	.0001	.0001
Imageability * S...	23	220.990	9.608				
Frequency * Ima...	1	3.010	3.010	.487	.4924	.4924	.4924
Frequency * Ima...	23	142.240	6.184				

Dependent: specificity score

Means Table
Effect: Imageability
Dependent: specificity score
specificity

	Count	Mean	Std. Dev.	Std. Error
High	48	18.875	2.385	.344
low	48	14.646	3.981	.575

Means Table
Effect: Frequency * Imageability
Dependent: specificity score
specificity

	Count	Mean	Std. Dev.	Std. Error
high f High i	24	19.333	2.496	.510
highf lowi	24	14.750	3.566	.728
lowf highi	24	18.417	2.225	.454
lowf lowi	24	14.542	4.433	.905

Experiment 1.

Analysis of variance on the specificity of memories retrieved in response to cues varying in imageability and frequency, (item analysis)
Between subject factors: imageability and frequency

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
Freq	1	.008	.008	.110	.7428
Imag	1	1.059	1.059	14.876	.0006
Freq * Imag	1	.011	.011	.158	.6939
Residual	28	1.992	.071		

Dependent: spec score

Means Table
Effect: Imag
Dependent: spec score

	Count	Mean	Std. Dev.	Std. Error
High	16	2.392	.264	.066
Low	16	2.028	.254	.063

Means Table
Effect: Freq * Imag
Dependent: spec score

	Count	Mean	Std. Dev.	Std. Error
High, High	8	2.426	.304	.107
High, Low	8	2.025	.296	.105
Low, High	8	2.358	.233	.082
Low, Low	8	2.031	.224	.079

Experiment 1.

Analysis of variance relating to the mean retrieval time of memories retrieved in response to cues varying in frequency and imageability, (item analysis)
Between subject factors: frequency and imageability

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
Frequency	1	.780	.780	.203	.6554
Imageability	1	157.784	157.784	41.138	.0001
Frequency * Ima...	1	2.153E-4	2.153E-4	5.61E-5	.9941
Residual	28	107.393	3.835		

Dependent: ret time

Means Table
Effect: Imageability
Dependent: ret time

	Count	Mean	Std. Dev.	Std. Error
high	16	6.823	1.401	.350
Low	16	11.264	2.291	.573

Means Table
Effect: Frequency * Imageability
Dependent: ret time

	Count	Mean	Std. Dev.	Std. Error
High, high	8	6.669	1.652	.584
High, Low	8	11.105	2.045	.723
Low, high	8	6.976	1.192	.421
Low, Low	8	11.422	2.648	.936

Table 4.2. Analysis of variance on the mean retrieval time of memories retrieved in response to cues varying in frequency and imageability, (subject analysis). Within subject factors: frequency and imageability

Type III Sums of Squares

Source	df	Sum of Squares	Mean Square	F-Value	P-Value	G-G	H-F
Subject	23	632.003	27.478				
Frequency	1	2.535	2.535	.478	.4963	.4963	.4963
Frequency * Sub...	23	121.993	5.304				
Imageability	1	470.643	470.643	40.887	.0001	.0001	.0001
Imageability * S...	23	264.748	11.511				
Frequency * Ima...	1	.383	.383	.079	.7807	.7807	.7807
Frequency * Ima...	23	110.863	4.820				

Dependent: latency times

Means Table
Effect: Imageability
Dependent: latency times

	Count	Mean	Std. Dev.	Std. Error
High I.	48	6.904	2.153	.311
Low I.	48	11.332	4.412	.637

Means Table
Effect: Frequency * Imageability
Dependent: latency times

	Count	Mean	Std. Dev.	Std. Error
High F, High I.	24	6.669	1.990	.406
High F, Low I.	24	11.106	4.057	.828
Low F., High I.	24	7.000	2.343	.478
Low F., Low I.	24	11.442	4.817	.983

Experiment 1. Analysis of variance on the age of memories retrieved in response to cues varying in imageability and frequency.
Within subject factors: imageability and frequency

Source	df	Sum of Squares	Mean Square	F-Value	P-Value	G-G	H-F
Subject	23	1.396	.061				
frequency	1	.001	.001	.024	.8779	.8779	.8779
frequency * Sub...	23	1.287	.056				
imageability	1	.045	.045	1.679	.2080	.2080	.2080
imageability * S...	23	.618	.027				
frequency * ima...	1	.006	.006	.104	.7500	.7500	.7500
frequency * ima...	23	1.331	.058				

Dependent: age of mems

Table of Epsilon Factors for df Adjustment
Dependent: ageof mems

	G-G Epsilon	H-F Epsilon
frequency	1.000	1.000
imageability	1.000	1.000
frequency * image...	1.000	1.000

Means Table
Effect: frequency * imageability
Dependent: ageof mems

	Count	Mean	Std. Dev.	Std. Error
highf highi	24	.892	.125	.026
highflowi	24	.832	.301	.061
lowf highi	24	.883	.118	.024
lowf lowi	24	.856	.285	.058

The Anova summary tables for subjective ratings of memory specificity, pleasantness and memory vividness are tabulated as follows;

Table 4.3 : Vividness Ratings

Source	df	Sum of Squares	Mean Square	F-Value	P-Value	G-G	H-F
Subject	23	18.649	.811				
frequency	1	.024	.024	.295	.5920	.5920	.5920
frequency * Sub...	23	1.898	.083				
imageability	1	2.016	2.016	10.212	.0040	.0040	.0040
imageability * S...	23	4.539	.197				
frequency * ima...	1	.026	.026	.167	.6870	.6870	.6870
frequency * ima...	23	3.637	.158				

Dependent: vividness ratings

Means Table
Effect: imageability
Dependent: vividness ratings

	Count	Mean	Std. Dev.	Std. Error
high i	48	4.124	.554	.080
low i	48	3.834	.553	.080

Means Table
Effect: frequency * imageability
Dependent: vividness ratings

	Count	Mean	Std. Dev.	Std. Error
high f, high i	24	4.156	.587	.120
high f, low i	24	3.833	.533	.109
low f, high i	24	4.091	.529	.108
low f, low i	24	3.835	.584	.119

Experiment 1.

Table 4.3 Anova summary table relating to subjective memory specificity ratings.

Source	df	Sum of Squares	Mean Square	F-Value	P-Value	G-G	H-F
Subject	23	25.398	1.104				
freq	1	.196	.196	.889	.3556	.3556	.3556
freq * Subject	23	5.077	.221				
IMAG	1	10.153	10.153	37.248	.0001	.0001	.0001
IMAG * Subject	23	6.269	.273				
freq * IMAG	1	.137	.137	.603	.4453	.4453	.4453
freq * IMAG * S...	23	5.206	.226				

Dependent : subjective specificity ratings

Means Table. Subjective Specificity Ratings

	Count	Mean	Std. Dev.	Std. Error
highI	48	3.909	.618	.089
LowI	48	3.259	.719	.104

Means Table Effect; Imageability x Frequency

	Count	Mean	Std. Dev.	Std. Error
highF, highI	24	3.917	.623	.127
highF, LowI	24	3.342	.680	.139
lowF, highI	24	3.902	.627	.128
lowF, LowI	24	3.176	.762	.156

Experiment 1.

Table 4.3 Anova summary table relating to mean pleasantness ratings.

Source	df	Sum of Squares	Mean Square	F-Value	P-Value	G-G	H-F
Subject	23	15.762	.685				
frequency	1	2.785	2.785	18.498	.0003	.0003	.0003
frequency * Sub...	23	3.462	.151				
imageability	1	18.559	18.559	88.723	.0001	.0001	.0001
imageability * S...	23	4.811	.209				
frequency * ima...	1	3.223	3.223	19.909	.0002	.0002	.0002
frequency * ima...	23	3.723	.162				

Dependent: pleasantness ratings

Means Table
Effect: frequency
Dependent: pleasantness ratings

	Count	Mean	Std. Dev.	Std. Error
high	48	3.296	.600	.087
low	48	2.955	.833	.120

Means Table
Effect: imageability
Dependent: pleasantness ratings

	Count	Mean	Std. Dev.	Std. Error
high	48	3.565	.449	.065
low	48	2.686	.719	.104

Means Table
Effect: frequency * imageability
Dependent: pleasantness ratings

	Count	Mean	Std. Dev.	Std. Error
highf highi	24	3.552	.488	.100
highf lowi	24	3.039	.600	.123
lowf highi	24	3.578	.417	.085
lowf lowi	24	2.332	.659	.135

Chapter 5.

Experiment 2. Imagery, modality effects and autobiographical memory.

Analysis of variance on the specificity of memories retrieved in response to different cue modalities, (item analysis)
Between subject factors: auditory, visual, motor, olfactory, tactile and abstract cues.

Type III Sums of Squares

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
modality	5	1.618	.324	7.956	.0001
Residual	30	1.220	.041		

Dependent: spec score

Means Table
Effect: modality
Dependent: spec score

	Count	Mean	Std. Dev.	Std. Error
visual	6	2.575	.227	.093
olfatory	6	2.450	.164	.067
tactile	6	2.458	.142	.058
auditory	6	2.632	.175	.071
morot	6	2.602	.186	.076
abstract	6	2.005	.282	.115

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
modality	5	110.357	22.071	12.222	.0001
Residual	30	54.176	1.806		

Dependent: meanrt

Means Table
Effect: modality
Dependent: meanrt

	Count	Mean	Std. Dev.	Std. Error
visual	6	7.707	.866	.353
olfactory	6	8.212	1.021	.417
tactile	6	9.837	2.115	.863
auditory	6	8.290	.859	.351
motor	6	9.480	1.415	.578
abstract	6	12.962	1.353	.552

Experiment 2

Table 5.3. Analysis of variance relating to the specificity of memories retrieved in response to different cue modalities, (subject analysis)
Within subject factors: visual, auditory, motor, tactile, olfactory, and abstract cues

Source	df	Sum of Squares	Mean Square	F-Value	P-Value	G-G	H-F
Subject	23	697.271	30.316				
modality	5	630.313	126.063	27.674	.0001	.0001	.0001
modality * Su...	115	523.854	4.555				

Dependent: memory specificity

Table of Epsilon Factors for df Adjustment
Dependent: imagery

	G-G Epsilon	H-F Epsilon
modality	.789	.973

Means Table
Effect: modality
Dependent: imagery

	Count	Mean	Std. Dev.	Std. Error
visual	24	15.375	2.446	.499
olfactory	24	13.792	2.874	.587
tactile	24	13.542	3.230	.659
auditory	24	15.167	2.239	.457
motor	24	14.375	3.437	.701
abstract	24	9.125	3.405	.695

Experiment 2.

Table 5.3. Analysis of variance on the mean retrieval time of memories retrieved in response to different cue modalities, (subject analysis)
Within subject factors: visual, auditory, motor, olfactory, tactile and abstract cues

Type III Sums of Squares

Source	df	Sum of Squares	Mean Square	F-Value	P-Value	G-G	H-F
Subject	23	1038.551	45.154				
modality	5	416.614	83.323	13.867	.0001	.0001	.0001
modality * Su...	115	691.014	6.009				

Dependent: sub ret time

Table of Epsilon Factors for df Adjustment
Dependent: sub ret time

	G-G Epsilon	H-F Epsilon
modality	.685	.820

Means Table
Effect: modality
Dependent: sub ret time

	Count	Mean	Std. Dev.	Std. Error
visual	24	7.624	2.767	.565
olfactory	24	8.280	3.699	.755
tactile	24	9.799	4.165	.850
auditory	24	8.229	2.591	.529
motor	24	9.410	3.327	.679
abstract	24	12.782	4.327	.883

Experiment 2.

Table 5.4. Anova summary table relating to mean pleasantness ratings (item analysis).

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
modality	5	3.215	.643	2.766	.0360
Residual	30	6.976	.233		

Dependent: meanpleas

Means Table
Effect: modality
Dependent: meanpleas

	Count	Mean	Std. Dev.	Std. Error
abstract	6	2.947	.286	.117
visual	6	3.898	.417	.170
olfactory	6	3.188	.601	.245
motor	6	3.115	.244	.100
tactile	6	3.315	.467	.190
auditory	6	3.205	.708	.289

Table 5.4. Anova summary table relating to mean vividness ratings

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
modality	5	2.079	.416	7.530	.0001
Residual	30	1.657	.055		

Dependent: mean vivid

Means Table
Effect: modality
Dependent: mean vivid

	Count	Mean	Std. Dev.	Std. Error
abstract	6	3.590	.162	.066
visual	6	4.258	.261	.107
olfactory	6	4.220	.193	.079
motor	6	3.795	.195	.080
tactile	6	4.125	.144	.059
auditory	6	4.080	.375	.153

Experiment 2.

Anova summary table referring to age of memories retrieved in response to different cue modalities.
Between subject factors: visual, olfactory, tactile, motor, auditory and abstract cues.

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
imagery	5	.032	.006	1.696	.1661
Residual	30	.115	.004		

Dependent: age of memory

Means Table
Effect: imagery
Dependent: age

	Count	Mean	Std. Dev.	Std. Error
visual	6	.900	.063	.026
olfactory	6	.833	.082	.033
tactile	6	.833	.052	.021
auditory	6	.833	.082	.033
motor	6	.850	.055	.022
abstract	6	.900	•	•

TABLE 5.7 Multiple Regression Analysis Stepwise Model 1

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. SPECMEM

Block Number 1. Method: Stepwise Criteria PIN .0500 POUT .1000
AUDITORY CONCEPTI MOTORIM OLFACTIM TACTILEI VISUALIM

Variable(s) Entered on Step number
1.. VISUALIM

Multiple R	.53161
R Square	.28261
Adjusted R Square	.26151
Standard Error	3.64303

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	177.76375	177.76375
Residual	34	451.23625	13.27165

F = 13.39424 Signif F = .0008

Variables in the Equation

Variable	B	SE B	Beta	T	Sig T
VISUALIM	1.327652	.362765	.531614	3.660	.0008
(Constant)	9.685732	1.531978		6.322	.0000

Variables not in Equation

Variable	Beta In	Partial	Min Toler	T	Sig T
AUDITORY	.433481	.488644	.911590	3.217	.0029
CONCEPTI	.105545	.120133	.929406	.695	.4918
MOTORIM	.368460	.414617	.908378	2.617	.0133
OLFACTIM	-.073489	-.072515	.698482	-.418	.6789
TACTILEI	-.201922	-.203507	.728695	-1.194	.2410

TABLE 5.7 (Continued) Multiple Regression Analysis Step 2

Equation Number 1 Dependent Variable.. SPECMEM

Variable(s) Entered on Step number
2.. AUDITORY

Multiple R	.67373
R Square	.45391
Adjusted R Square	.42081
Standard Error	3.22628

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	2	285.50693	142.75346
Residual	33	343.49307	10.40888

F = 13.71458 Signif F = .0000

Variables in the Equation

Variable	B	SE B	Beta	T	Sig T
AUDITORY	.939959	.292157	.433481	3.217	.0029
VISUALIM	1.649543	.336484	.660504	4.902	.0000
(Constant)	5.996406	1.776415		3.376	.0019

Variables not in Equation

Variable	Beta In	Partial	Min Toler	T	Sig T
CONCEPTI	.143592	.186630	.862563	1.075	.2906
MOTORIM	.092690	.078036	.387077	.443	.6609
OLFACTIM	.055725	.060961	.653530	.345	.7320
TACTILEI	-.221452	-.255611	.673356	-1.496	.1445

End Block Number 1 PIN = .050 Limits reached.

TABLE 5.7 Multiple Regression Analysis Stepwise Model 1

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. MEANRT

Block Number 1. Method: Stepwise Criteria PIN .0500 POUT .1000
AUDITORY CONCEPTI MOTORIM OLFACTIM TACTILEI VISUALIM

Variable(s) Entered on Step number
1.. VISUALIM

Multiple R	.59283
R Square	.35145
Adjusted R Square	.33237
Standard Error	1.75828

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	56.95980	56.95980
Residual	34	105.11295	3.09156

F = 18.42431 Signif F = .0001

Variables in the Equation

Variable	B	SE B	Beta	T	Sig T
VISUALIM	-.751531	.175086	-.592829	-4.292	.0001
(Constant)	12.224964	.739398		16.534	.0000

Variables not in Equation

Variable	Beta In	Partial	Min Toler	T	Sig T
AUDITORY	-.490701	-.581759	.911590	-4.109	.0002
CONCEPTI	-.102034	-.122145	.929406	-.707	.4846
MOTORIM	-.376486	-.445563	.908378	-2.859	.0073
OLFACTIM	.015718	.016312	.698482	.094	.9259
TACTILEI	.135134	.143240	.728695	.831	.4117

TABLE 5.8 (Continued) Multiple Regression Analysis Step 2

Equation Number 1 Dependent Variable.. MEANRT

Variable(s) Entered on Step number
2.. AUDITORY

Multiple R	.75561
R Square	.57095
Adjusted R Square	.54494
Standard Error	1.45163

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	2	92.53464	46.26732
Residual	33	69.53811	2.10722

F = 21.95662 Signif F = .0000

Variables in the Equation

Variable	B	SE B	Beta	T	Sig T
AUDITORY	-.540114	.131452	-.490701	-4.109	.0002
VISUALIM	-.936494	.151397	-.738733	-6.186	.0000
(Constant)	14.344904	.799276		17.947	.0000

Variables not in Equation

Variable	Beta In	Partial	Min Toler	T	Sig T
CONCEPTI	-.144973	-.212577	.862563	-1.231	.2274
MOTORIM	-.009620	-.009137	.387077	-.052	.9591
OLFACTIM	-.135194	-.166853	.653530	-.957	.3456
TACTILEI	.157096	.204570	.673356	1.182	.2458

End Block Number 1 PIN = .050 Limits reached.

Chapter 6.

Experiment 3

Table 6.2. Anova summary table relating to between group specificity (induction phase).

Between subject factor: Imageability

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
group	1	1200.118	1200.118	57.653	.0001
Residual	32	666.118	20.816		

Dependent: spec score

Means Table
Effect: group
Dependent: spec score

	Count	Mean	Std. Dev.	Std. Error
HI	17	41.529	3.986	.967
LI	17	29.647	5.074	1.231

TABLE 7.5 MULTIPLE REGRESSION ANALYSIS STEPWISE MODELS

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. SPECMEM

Block Number 1. Method: Stepwise Criteria PIN .0500 POUT .1000
AUDITORY MOTORIM OLFACTIM PREDRATE TACTILE

Variable(s) Entered on Step number
1.. PREDRATE

Multiple R	.57886
R Square	.33508
Adjusted R Square	.31552
Standard Error	3.50729

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	210.76237	210.76237
Residual	34	418.23763	12.30111

F = 17.13361 Signif F = .0002

Variables in the Equation

Variable	B	SE B	Beta	T	Sig T
PREDTIME	-.291432	.070406	-.578857	-4.139	.0002
(Constant)	23.497271	2.173197		10.812	.0000

Variables not in Equation

Variable	Beta In	Partial	Min Toler	T	Sig T
AUDITORY	.240299	.294686	.999969	1.772	.0857
MOTORIM	.326199	.371693	.863327	2.300	.0279
OLFACTIM	.123150	.137393	.827626	.797	.4313
PREDRATE	.171625	.143998	.468087	.836	.4092
TACTILEI	-.254157	-.262982	.711906	-1.566	.1269

TABLE 7.5 MULTIPLE REGRESSION ANALYSIS STEPWISE MODELS

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. SPECMEM

Block Number 1. Method: Stepwise Criteria PIN .0500 POUT .1000
AUDITORY MOTORIM OLFACTIM PREDRATE TACTILE

Variable(s) Entered on Step number
1.. PREDRATE

Multiple R	.57886
R Square	.33508
Adjusted R Square	.31552
Standard Error	3.50729

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	210.76237	210.76237
Residual	34	418.23763	12.30111

F = 17.13361 Signif F = .0002

Variables in the Equation

Variable	B	SE B	Beta	T	Sig T
PREDTIME	-.291432	.070406	-.578857	-4.139	.0002
(Constant)	23.497271	2.173197		10.812	.0000

Variables not in Equation

Variable	Beta In	Partial	Min Toler	T	Sig T
AUDITORY	.240299	.294686	.999969	1.772	.0857
MOTORIM	.326199	.371693	.863327	2.300	.0279
OLFACTIM	.123150	.137393	.827626	.797	.4313
PREDRATE	.171625	.143998	.468087	.836	.4092
TACTILEI	-.254157	-.262982	.711906	-1.566	.1269

TABLE 7.5 (Continued) Multiple Regression Analysis Step 2

Equation Number 1 Dependent Variable.. SPECMEM

Variable(s) Entered on Step number
2.. MOTORIM

Multiple R	.65341
R Square	.42694
Adjusted R Square	.39221
Standard Error	3.30498

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	2	268.54431	134.27216
Residual	33	360.45569	10.92290

F = 12.29272 Signif F = .0001

Variables in the Equation

Variable	B	SE B	Beta	T	Sig T
MOTORIM	1.191869	.518205	.326199	2.300	.0279
PREDTIME	-.230717	.071404	-.458263	-3.231	.0028
(Constant)	17.479051	3.322703		5.260	.0000

Variables not in Equation

Variable	Beta In	Partial	Min Toler	T	Sig T
AUDITORY	.075926	.076452	.501632	.434	.6674
OLFACTOR	.275774	.309923	.638450	1.844	.0745
TACTILE	.008138	.006828	.403458	.039	.9694
PREDRATE	-.308279	-.340455	.664972	-2.048	.0488

TABLE 7.5 (Continued) Multiple Regression Analysis Step 3

Equation Number 1 Dependent Variable.. SPECMEM

Variable(s) Entered on Step number
3.. TACTILE

Multiple R	.70240
R Square	.49336
Adjusted R Square	.44586
Standard Error	3.15573

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	3	310.32459	103.44153
Residual	32	318.67541	9.95861

F = 10.38715 Signif F = .0001

Variables in the Equation

Variable	B	SE B	Beta	T	Sig T
MOTORIM	1.329976	.499375	.363998	2.663	.0120
PREDTIME	-.306988	.077685	-.609756	-3.952	.0004
TACTILE	-.877842	.428578	-.308279	-2.048	.0488
(Constant)	21.805982	3.811599		5.721	.0000

Variables not in Equation

Variable	Beta In	Partial	Min Toler	T	Sig T
AUDITORY	-.029390	-.029989	.456307	-.167	.8684
OLFACTOR	.268561	.320897	.517990	1.886	.0686
PREDRATE	.227012	.182505	.327454	1.034	.3094

End Block Number 1 PIN = .050 Limits reached.

Chapter 9.

Table 9.1 Experiment 4 Anova summary table for randomisation measures.

Between subject factor: group

Auto-correlation index

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
group	3	1.238	.413	1.187	.3206
Residual	76	26.441	.348		

Dependent: ACi

Means Table
Effect: group
Dependent: ACi

	Count	Mean	Std. Dev.	Std. Error
tables	20	3.349	.574	.128
humans	20	3.499	.674	.151
qbasic	20	3.197	.560	.125
marsaglia	20	3.201	.542	.121

Table 9.1: Anova summary table relating to mean difference measures

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
Group	3	.616	.205	2.340	.0800
Residual	76	6.664	.088		

Dependent: mean diff

Means Table
Effect: Group
Dependent: mean diff

	Count	Mean	Std. Dev.	Std. Error
tables	20	4.132	.240	.054
humans	20	4.295	.330	.074
q basic	20	4.105	.277	.062
marsaglia	20	4.064	.327	.073

Table 9.1: Anova summary table relating to phase measures of randomness

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
group	3	398.650	132.883	4.408	.0065
Residual	76	2290.900	30.143		

Dependent: Phase

Means Table
Effect: group
Dependent: Phase

	Count	Mean	Std. Dev.	Std. Error
tables	20	61.950	4.211	.942
humans	20	65.200	7.824	1.750
qbasic	20	59.450	4.136	.925
marasglia	20	60.100	4.951	1.107

Table 9.1 Anova summary table relating to Chi measures of randomness

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
Group	3	80.260	26.753	.592	.6219
Residual	76	3432.252	45.161		

Dependent: Chi

Means Table
Effect: Group
Dependent: Chi

	Count	Mean	Std. Dev.	Std. Error
tables	20	7.580	5.332	1.192
humans	20	10.305	11.464	2.563
qbasic	20	8.380	3.176	.710
marsaglia	20	8.410	3.273	.732

Table 9.1 Anova summary table relating to Triplet measures of randomness

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
Gps	3	1462.700	487.567	12.603	.0001
Residual	76	2940.100	38.686		

Dependent: trips

Means Table
Effect: Gps
Dependent: trips

	Count	Mean	Std. Dev.	Std. Error
tables	20	88.400	4.806	1.075
humans	20	78.900	9.301	2.080
qbasic	20	89.750	4.678	1.046
marsaglia	20	87.750	4.822	1.078

Table 9.1 Anova summary table relating to Evans Rng measures of randomness

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
Group	3	.055	.018	20.132	.0001
Residual	76	.069	.001		

Dependent: RNG

Means Table
Effect: Group
Dependent: RNG

	Count	Mean	Std. Dev.	Std. Error
tables	20	.233	.025	.006
humans	20	.299	.046	.010
q basic	20	.244	.021	.005
marsaglia	20	.242	.020	.005

Chapter 10

Table 10.1
Experiment 6 (a). Anova summary table relating to Memory Span task in single and combined conditions.
Within subject factors: trial condition and sequence length

Source	df	Sum of Squares	Mean Square	F-Value	P-Value	G-G	H-F
Subject	25	25183.082	1007.323				
Trial condition	1	2000.120	2000.120	20.628	.0001	.0001	.0001
Trial condition *...	25	2424.005	96.960				
Sequence length	3	139875.322	46625.107	109.395	.0001	.0001	.0001
Sequence length ...	75	31965.553	426.207				
Trial condition *...	3	1762.438	587.479	5.421	.0020	.0111	.0096
Trial condition *...	75	8127.937	108.372				

Dependent: digit span % correct

Means Table
Effect: Trial condition * Sequence length
Dependent: digit span % correct

	Count	Mean	Std. Dev.	Std. Error
single, Two	26	100.000	0.000	0.000
single, four	26	99.769	1.177	.231
single, six	26	84.885	15.531	3.046
single, eight	26	42.692	32.442	6.362
combinedRNG, Two	26	100.000	0.000	0.000
combinedRNG, four	26	98.885	3.626	.711
combinedRNG, six	26	74.038	26.457	5.189
combinedRNG, eight	26	29.615	26.455	5.188

Experiment 6 (a) The effect of memory span task on random generation

Table 10.2 Anova summary table relating to the effect of concurrent memory span task on the randomness of the keypressing task.
Within subject factor: trial condition

Source	df	Sum of Squares	Mean Square	F-Value	P-Value	G-G	H-F
Subject	21	.641	.031				
Rng	4	.134	.033	7.410	.0001	.0008	.0004
Rng * Subject	84	.380	.005				

Dependent: randomness

Table of Epsilon Factors for df Adjustment
Dependent: randomness

	G-G Epsilon	H-F Epsilon
Rng	.604	.688

Means Table
Effect: Rng
Dependent: randomness

	Count	Mean	Std. Dev.	Std. Error
baseline	22	.318	.061	.013
two	22	.373	.071	.015
four	22	.387	.106	.023
six	22	.405	.146	.031
eight	22	.418	.086	.018

Table 10.3. Anova summary table relating to mean % omission scores (errors)

Within subject factor: trial condition

Source	df	Sum of Squares	Mean Square	F-Value	P-Value	G-G	H-F
Subject	21	3981.100	189.576				
No of omissions	4	2544.236	636.059	13.479	.0001	.0001	.0001
No of omission...	84	3963.764	47.188				

Dependent: errors

Table of Epsilon Factors for df Adjustment
Dependent: errors

	G-G Epsilon	H-F Epsilon
No of omi...	.761	.905

Means Table
Effect: No of omissions
Dependent: errors

	Count	Mean	Std. Dev.	Std. Error
two	22	7.545	8.700	1.855
four	22	6.682	9.930	2.117
six	22	12.591	10.285	2.193
eight	22	15.227	9.666	2.061
baseline	22	1.455	2.198	.469

Table 10.4. Anova summary table relating to the effect of concurrent keypressing on memory span performance.
Between subject factor: group or sequence order
Within subject factors: trial condition and sequence length

Source	df	Sum of Squares	Mean Square	F-Value	P-Value	G-G	H-F
Group	1	202.500	202.500	.461	.5057		
Subject(Group)	18	7903.250	439.069				
Condition	1	1537.600	1537.600	26.072	.0001	.0001	.0001
Condition * Group	1	57.600	57.600	.977	.3361	.3361	.3361
Condition * Subj...	18	1061.550	58.975				
Sequence Length	3	118358.650	39452.883	181.765	.0001	.0001	.0001
Sequence Length...	3	530.150	176.717	.814	.4916	.4023	.4121
Sequence Length...	54	11720.950	217.055				
Condition * Sequ...	3	1653.650	551.217	9.023	.0001	.0017	.0010
Condition * Sequ...	3	42.750	14.250	.233	.8728	.7452	.7751
Condition * Sequ...	54	3298.850	61.090				

Dependent: Mean Correct sequences

Table of Epsilon Factors for df Adjustment
Dependent: Mean Correct sequences

	G-G Epsilon	H-F Epsilon
Condition	1.000	1.059
Sequence Length	.416	.456
Condition * Sequen...	.536	.613

NOTE: Probabilities are not corrected for values of epsilon greater than 1.

Means Table
Effect: Condition * Sequence Length
Dependent: Mean Correct sequences

	Count	Mean	Std. Dev.	Std. Error
Single, Two	20	100.000	0.000	0.000
Single, four	20	99.850	.671	.150
Single, Six	20	90.350	8.475	1.895
Single, Eight	20	41.700	25.278	5.652
Combined, Two	20	100.000	0.000	0.000
Combined, four	20	99.000	1.622	.363
Combined, Six	20	82.350	14.989	3.352
Combined, Eight	20	25.750	19.175	4.288

Table 10.5. Anova summary table above relating to the effect of the immediate memory span task on the random keypressing task.
Within subject factor: trial condition.

Source	df	Sum of Squares	Mean Square	F-Value	P-Value	G-G	H-F
Subject	19	.294	.015				
Trials	4	.149	.037	14.030	.0001	.0001	.0001
Trials * Subject	76	.202	.003				

Dependent: Evans Index

Table of Epsilon Factors for df Adjustment
Dependent: Evans Index

	G-G Epsilon	H-F Epsilon
Trials	.608	.704

Means Table
Effect: Trials
Dependent: Evans Index

	Count	Mean	Std. Dev.	Std. Error
baseline	20	.323	.039	.009
two	20	.344	.047	.011
four	20	.366	.071	.016
six	20	.391	.081	.018
eight'	20	.435	.104	.023

Table 10.6. Anova summary table relating to omission (error) analysis in keypressing with concurrent memory span task.
Within subject factor: trial condition

Source	df	Sum of Squares	Mean Square	F-Value	P-Value	G-G	H-F
Subject	19	2852.600	150.137				
cond	4	3418.000	854.500	48.814	.0001	.0001	.0001
base * Subject	76	1330.400	17.505				

Dependent: %errors

Table of Epsilon Factors for df Adjustment
Dependent: %errors

	G-G Epsilon	H-F Epsilon
cond	.749	.905

Means Table
Effect: condition
Dependent: %errors

	Count	Mean	Std. Dev.	Std. Error
baseline	20	1.750	2.918	.652
two	20	10.350	7.110	1.590
four	20	12.650	7.569	1.693
six	20	15.800	6.818	1.525
eight	20	18.950	7.571	1.693

Table 11.5

Experiment 7 (a) Anova summary table relating to the specificity of memories retrieved. Within subject factors: imageability and memory trial.

Type III Sums of Squares

Source	df	Sum of Squares	Mean Square	F-Value	P-Value	G-G	H-F
Subject	25	61.279	2.451				
trial	1	7.010	7.010	3.917	.0589	.0689	.0589
trial * Subject	25	44.740	1.790				
imageability	1	110.087	110.087	58.979	.0001	.0001	.0001
imageability * S...	25	46.663	1.867				
trial * imageabil...	1	21.240	21.240	8.495	.0074	.0074	.0074
trial * imageabil...	25	62.510	2.500				

Dependent: spec score

Means Table
Effect: trial * imageability
Dependent: spec score

	Count	Mean	Std. Dev.	Std. Error
single, high	26	7.654	1.355	.266
single, low	26	6.500	1.421	.279
combined, high	26	8.038	.871	.171
combined, low	26	5.077	1.998	.392

Table 11.7 Anova summary table relating to the number of general memories recalled
Within subject factors: imageability and trial condition

Type III Sums of Squares

Source	df	Sum of Squares	Mean Square	F-Value	P-Value	G-G	H-F
Subject	25	21.125	.845				
conditions	1	1.625	1.625	7.927	.0094	.0094	.0094
conditions * Sub...	25	5.125	.205				
imageability	1	2.163	2.163	9.682	.0046	.0046	.0046
imageability * S...	25	5.587	.223				
conditions * ima...	1	1.625	1.625	4.452	.0450	.0450	.0450
conditions * ima...	25	9.125	.365				

Dependent: no.of general mems

Table of Epsilon Factors for df Adjustment
Dependent: no of general mems

	G-G Epsilon	H-F Epsilon
conditions	1.000	1.000
imageability	1.000	1.000
conditions * image...	1.000	1.000

Means Table
Effect: imageability
Dependent: no of general mems

	Count	Mean	Std. Dev.	Std. Error
high	52	2.481	.779	.108
low	52	2.769	.509	.071

Means Table
Effect: conditions * imageability
Dependent: no of general mems

	Count	Mean	Std. Dev.	Std. Error
single, high	26	2.731	.533	.105
single, low	26	2.769	.514	.101
combined, high	26	2.231	.908	.178
combined, low	26	2.769	.514	.101

Table 11.9 Anova summary table relating to mean % omission scores on keypressing task
Within subject factors: trial conditions

Source	df	Sum of Squares	Mean Square	F-Value	P-Value	G-G	H-F
Subject	22	4195.061	190.685				
condition	4	1619.339	404.835	12.967	.0001	.0001	.0001
condition * Su...	88	2747.461	31.221				

Dependent: %omissions

Table of Epsilon Factors for df Adjustment
Dependent: %omissions

	G-G Epsilon	H-F Epsilon
condition	.749	.880

Table of Epsilon Factors for df Adjustment
Dependent: %omissions

	G-G Epsilon	H-F Epsilon
condition	.749	.880

Means Table
Effect: condition
Dependent: %omissions

	Count	Mean	Std. Dev.	Std. Error
base	23	1.261	2.158	.450
specch	23	11.522	9.409	1.962
specl	23	11.000	8.837	1.843
genh	23	7.261	6.930	1.445
genl	23	9.783	9.812	2.046

Anova summary table relating to factorial analysis of % omissions in keypresssing task.
Within subject factors: imageability and memory instruction

Source	df	Sum of Squares	Mean Square	F-Value	P-Value	G-G	H-F
Subject	22	4957.413	225.337				
Autobiomem	1	172.565	172.565	3.357	.0805	.0805	.0805
Autobiomem * S...	22	1130.935	51.406				
Imageability	1	23.000	23.000	1.678	.2086	.2086	.2086
Imageability * S...	22	301.500	13.705				
Autobiomem * I...	1	53.261	53.261	2.602	.1210	.1210	.1210
Autobiomem * I...	22	450.239	20.465				

Dependent: %E

Means Table
Effect: Autobiomem * Imageability
Dependent: %E

	Count	Mean	Std. Dev.	Std. Error
specific, High	23	11.522	9.409	1.962
specific, low	23	11.000	8.837	1.843
general, High	23	7.261	6.930	1.445
general, low	23	9.783	9.812	2.046

Table 11.11. Anova summary table relating to the specificity of memories retrieved in combined trials.
Within subject factors: imageability and type of memory instruction

Source	df	Sum of Squares	Mean Square	F-Value	P-Value	G-G	H-F
Subject	36	790.176	21.949				
instructions	1	2141.682	2141.682	176.002	.0001	.0001	.0001
instructions * S...	36	438.068	12.169				
imageability	1	740.277	740.277	77.141	.0001	.0001	.0001
imageability * S...	36	345.473	9.596				
instructions * i...	1	123.142	123.142	19.392	.0001	.0001	.0001
instructions * i...	36	228.608	6.350				

Dependent: memory specificity

Means Table
Effect: instructions
Dependent: memory specificity

	Count	Mean	Std. Dev.	Std. Error
specific	74	23.149	5.218	.607
general	74	15.541	3.048	.354

Means Table
Effect: imageability
Dependent: memory specificity

	Count	Mean	Std. Dev.	Std. Error
high	74	21.581	5.384	.626
low	74	17.108	5.170	.601

Means Table
Effect: instructions * imageability
Dependent: memory specificity

	Count	Mean	Std. Dev.	Std. Error
specific , high	37	26.297	2.980	.490
specific , low	37	20.000	5.094	.837
general, high	37	16.865	2.043	.336
general, low	37	14.216	3.326	.547

Table 11.13 Anova summary table relating to the retrieval of categoric and extended non specific autobiographical memories

Source	df	Sum of Squares	Mean Square	F-Value	P-Value	G-G	H-F
Subject	36	142.068	3.946				
instructions	1	80.277	80.277	13.538	.0008	.0008	.0008
instructions * S...	36	213.473	5.930				
imageability	1	3.574	3.574	1.338	.2550	.2550	.2550
imageability * S...	36	96.176	2.672				
instructions * i...	1	66.223	66.223	30.751	.0001	.0001	.0001
instructions * i...	36	77.527	2.154				

Dependent: no of categoric mems

Means Table
Effect: instructions * imageability
Dependent: no of categoric mems

	Count	Mean	Std. Dev.	Std. Error
generic, high	37	4.757	2.019	.332
generic, low	37	3.108	2.118	.348
specific, high	37	1.946	1.699	.279
specific, low	37	2.973	1.803	.296

Means Table
Effect: instructions
Dependent: no of categoric mems

	Count	Mean	Std. Dev.	Std. Error
generic	74	3.932	2.217	.258
specific	74	2.459	1.815	.211

Table 11.13. Anova summary table relating to the retreival of semantic autobiographical memories

Source	df	Sum of Squares	Mean Square	F-Value	P-Value	G-G	H-F
Subject	36	219.189	6.089				
instructions	1	525.953	525.953	185.091	.0001	.0001	.0001
instructions * S...	36	102.297	2.842				
imageability	1	58.439	58.439	28.122	.0001	.0001	.0001
imageability * S...	36	74.811	2.078				
instructions * i...	1	18.980	18.980	12.826	.0010	.0010	.0010
instructions * i...	36	53.270	1.480				

Dependent: no of sems

Means Table
Effect: instructions
Dependent: no of sems

	Count	Mean	Std. Dev.	Std. Error
general	74	4.365	2.475	.288
specific	74	.595	1.046	.122

Means Table
Effect: imageability
Dependent: no of sems

	Count	Mean	Std. Dev.	Std. Error
high	74	1.851	2.045	.238
low	74	3.108	3.072	.357

Means Table
Effect: instructions * imageability
Dependent: no of sems

	Count	Mean	Std. Dev.	Std. Error
general, high	37	3.378	1.769	.291
general, low	37	5.351	2.700	.444
specific, high	37	.324	.747	.123
specific, low	37	.865	1.228	.202

Table 11.14. Anova summary table relating to Rng index of randomness

Source	df	Sum of Squares	Mean Square	F-Value	P-Value	G-G	H-F
Subject	34	.328	.010				
Condition /trial	4	.128	.032	16.204	.0001	.0001	.0001
Condition /tri...	136	.269	.002				

Dependent: Evans RI

Table of Epsilon Factors for df Adjustment
Dependent: Evans RI

	G-G Epsilon	H-F Epsilon
Condition...	.881	.996

Means Table
Effect: Condition /trial
Dependent: Evans RI

	Count	Mean	Std. Dev.	Std. Error
baseline	35	.304	.043	.007
general high	35	.364	.056	.009
general low	35	.373	.069	.012
specific high	35	.378	.069	.012
specific low	35	.367	.056	.009

Table 11.14. Anova summary table relating to Triplet measure of randomness

Source	df	Sum of Squares	Mean Square	F-Value	P-Value	G-G	H-F
Subject	33	11910.053	360.911				
condition	4	3422.624	855.656	10.946	.0001	.0001	.0001
condition * Su...	132	10318.976	78.174				

Dependent: triplet measure

Table of Epsilon Factors for df Adjustment
Dependent: triplet measure

	G-G Epsilon	H-F Epsilon
condition	.897	1.019

NOTE: Probabilities are not corrected for values of epsilon greater than 1.

Means Table
Effect: condition
Dependent: triplet measure

	Count	Mean	Std. Dev.	Std. Error
baseline	34	78.353	8.731	1.497
specific high	34	65.971	12.614	2.163
specific low	34	68.618	11.680	2.003
general high	34	68.588	11.634	1.995
general low	34	66.618	12.903	2.213

Table 11.15. Anova summary table relating to % omission scores in Exp 7 (b)
Key pressing task.
Within subject factors: imageability and type of memory instruction

Source	df	Sum of Squares	Mean Square	F-Value	P-Value		
Subject	31	10396.969	335.386				
ABM	1	22.781	22.781	.852	.3632		
ABM * Subject	31	829.219	26.749				
Cue Status	1	11.281	11.281	.390	.5369		
Cue Status * Su...	31	896.719	28.926				
ABM * Cue Status	1	63.281	63.281	1.760	.1943		
ABM * Cue Stat...	31	1114.719	35.959				

Dependent: %error analysis

Means Table
Effect: ABM * Cue Status
Dependent: %error analysis

	Count	Mean	Std. Dev.	Std. Error
general, High	32	16.719	10.970	1.939
general, low	32	15.906	10.297	1.820
specific, High	32	16.156	10.113	1.788
specific, low	32	18.156	9.919	1.754

Table 11.15. Anova summary table relating to omissions in the autobiographical memory task

Within subject factors: imageability and instructions

Source	df	Sum of Squares	Mean Square	F-Value	P-Value	G-G	H-F
Subject	36	78.919	2.192				
instructions	1	10.811	10.811	19.277	.0001	.0001	.0001
instructions * S...	36	20.189	.561				
imagebility	1	37.000	37.000	19.588	.0001	.0001	.0001
imagebility * Su...	36	68.000	1.889				
instructions * i...	1	5.297	5.297	6.884	.0127	.0127	.0127
instructions * i...	36	27.703	.770				

Dependent: no of ommissions

Table of Epsilon Factors for df Adjustment
Dependent: no of ommissions

	G-G Epsilon	H-F Epsilon
instructions	1.000	1.000
imagebility	1.000	1.000
instructions * imag...	1.000	1.000

Means Table
Effect: instructions
Dependent: no of ommissions

	Count	Mean	Std. Dev.	Std. Error
general	74	.527	.968	.113
specific	74	1.068	1.520	.177

Means Table
Effect: imagebility
Dependent: no of ommissions

	Count	Mean	Std. Dev.	Std. Error
high	74	.297	.591	.069
low	74	1.297	1.594	.185

Means Table
Effect: instructions * imagebility
Dependent: no of ommissions

	Count	Mean	Std. Dev.	Std. Error
general, high	37	.216	.584	.096
general, low	37	.838	1.167	.192
specific, high	37	.378	.594	.098
specific, low	37	1.757	1.832	.301

Source	df	Sum of Squares	Mean Square	F-Value	P-Value	G-G	H-F
Subject	36	141.581	3.933				
instructions	1	1017.189	1017.189	260.984	.0001	.0001	.0001
instructions * S...	36	140.311	3.898				
imageability	1	39.027	39.027	11.662	.0016	.0016	.0016
imageability * S...	36	120.473	3.346				
instructions * i...	1	14.297	14.297	7.659	.0089	.0089	.0089
instructions * i...	36	67.203	1.867				

Dependent: no of combined gen

Means Table
Effect: instructions
Dependent: no of combined gen

	Count	Mean	Std. Dev.	Std. Error
general	74	8.338	1.529	.178
specific	74	3.095	2.197	.255

Means Table
Effect: imageability
Dependent: no of combined gen

	Count	Mean	Std. Dev.	Std. Error
high	74	5.203	3.364	.391
low	74	6.230	3.041	.354

Means Table
Effect: instructions * imageability
Dependent: no of combined gen

	Count	Mean	Std. Dev.	Std. Error
general, high	37	8.135	1.456	.239
general, low	37	8.541	1.592	.262
specific, high	37	2.270	1.774	.292
specific, low	37	3.919	2.290	.376

Experiment 1. Table 4.1

Frequency and imageability ratings of all cues used.

Cues	T.L.F.Frequency	K.F.Frequency	Imageability
Letter	AA	260	6.37
Grass	AA	55	6.63
Library	A	20	6.73
Lake	AA	61	6.67
Factory	A	56	6.43
Teacher	AA	152	5.71
Sea	AA	104	6.73
Baby	AA	80	6.70
Law	AA	387	3.71
Duty	AA	95	3.17
Opportunity	A	172	3.03
Interest	AA	408	3.13
Knowledge	AA	145	2.97
Effort	AA	272	3.33
Situation	A	247	2.53
Soul	A	73	2.13

Experiment 1. Table 4.1: Cue Ratings

Cues	T.L.F.Frequency	K.F.Frequency	Imageability
Bouquet	8	10	6.77
Poetry	26	90	4.90
Errand	20	7	4.27
Cradle	21	8	6.23
Photograph	6	29	6.43
Nun	9	6	6.67
Spinach	8	2	6.47
Robbery	9	13	5.00
Obedience	15	10	3.67
Boredom	1	11	3.83
Explanation	31	58	2.90
Hearing	13	56	3.71
Legislation	23	46	3.33
Mood	27	45	3.07
Permission	22	27	2.87
Upkeep	2	6	3.07

Table 5.1 Experiment 2. Cue Imageability Ratings

Visual Cues

word	Visual.	Olfactory.	Tactile	Auditory	Motor
butterfly	5.67	1.27	2.87	1.27	4.06
cloud	6.00	1.13	1.07	1.20	3.00
painting	5.53	2.00	3.40	1.13	4.38
fire	5.60	3.93	3.27	4.20	5.50
mountain	6.07	2.00	2.73	5.33	3.75
house	5.93	1.60	2.93	1.47	3.75

Olfactory cues

word	Visual	Olfactory	Tactile	Auditory	Motor
cheese	4.93	5.20	3.93	1.07	2.38
chlorine	1.67	5.27	1.47	1.00	2.13
rose	5.73	5.60	3.93	1.07	2.56
smoke	4.73	5.33	1.40	1.27	3.36
coffee	5.00	5.60	3.60	1.47	3.25
curry	4.13	5.40	2.93	1.07	3.00

Table 5.1.Tactile cues

word	Visual	Olfactory.	Tactile	Auditory	Motor
sponge	4.28	2.89	5.61	1.56	3.44
needle	3.67	1.17	4.06	1.06	3.17
can-opener	4.61	1.78	5.17	3.28	4.00
wool	4.67	1.87	5.47	1.07	2.69
satin	3.93	1.07	4.40	1.07	2.88
ice	5.00	1.13	5.07	1.93	3.06

Auditory cues

word	Visual	Olfactory	Tactile	Auditory	Motor
snore	1.27	1.07	1.47	5.80	3.94
thunder	2.40	1.00	1.13	6.33	3.75
whistle	2.53	1.00	1.73	6.40	3.56
choir	3.93	1.07	1.60	5.80	4.56
cry	2.00	1.00	1.73	6.00	4.56
laughter	1.67	1.00	1.47	6.33	5.00

Table 5.1 Motor cues

word	Visual	Olfactory	Tactile	Auditory	Motor
football	5.40	1.40	4.20	3.07	6.25
axe	3.94	1.33	4.11	4.44	4.44
pump	3.40	1.13	2.53	2.80	4.56
hammer	3.94	1.33	4.83	5.78	4.61
spade	3.83	1.83	4.44	3.06	4.11
racquet	4.44	1.67	4.39	3.11	5.67

Abstract cues

word	Visual	Olfactory.	Tactile	Auditory	Motor
wisdom	1.47	1.00	1.27	1.27	1.88
worth	1.13	1.00	1.20	1.00	1.31
moral	1.07	1.00	1.20	1.20	1.88
attitude	1.40	1.00	1.27	1.33	2.00
greed	1.40	1.00	1.20	1.13	1.94
thought	1.27	1.00	1.40	1.13	2.88

Experiment 4. Chapter 7

Table 7.1 Group A cues Predicability Measures

	Predicability Ratings	
	Predication Time	Predicability Rating
Word	Mean	Mean
Spinach	21.80 (6.02)	5.55(1.70)
Photograph	30.32 (9.49)	5.70 (1.38)
Bouquet	28.83 (9.15)	5.45 (1.23)
Errand	32.16(19.50)	4.25 (1.58)
Cradle	27.16 (8.72)	5.70 (1.32)
Boredom	36.99(11.04)	3.40(1.50)
Obedience	54.28 (30.40)	3.05(1.79)
Explanation	48.55(27.79)	3.10(1.25)
Permission	60.28(46.72)	3.60(1.78)
Upkeep	65.78(38.04)	2.55(1.73)
Legislation	44.39(23.70)	3.35(2.13)
Hearing	36.43(16.21)	4.95(1.82)
Mood	39.46(28.78)	1.80(1.36)
Sea	24.31(8.86)	6.45(1.39)
Baby	30.75(11.16)	6.80(0.52)
Teacher	35.66(19.36)	6.45 (0.94)
Soul	52.17 (32.69)	2.05(1.19)
Knowledge	53.25(36.80)	3.40(1.42)
Situation	53.38 (36.80)	3.80(1.82)
Factory	29.47 (7.06)	6.60(0.59)
Grass	21.83(9.98)	6.60(1.14)
Letter	33.51(24.40)	6.20(1.19)

Library	25.66(7.38)	6.25(1.16)
Lake	30.53(21.47)	6.40(0.99)
Law	42.65(32.14)	4.05(1.23)
Duty	47.88(34.76)	3.05(1.46)
Opportunity	55.64(32.59)	3.30(1.72)
Interest	48.28(30.21)	4.00(1.80)
Effort	57.70(40.02)	3.75(1.48)
Poetry	36.22(18.87)	4.35(1.78)
Robbery	39.27(26.85)	5.05(1.35)
Nun	26.57(10.33)	5.65(1.66)

Table 7.1

Experiment 4. Chapter 7. Group B cues . Predicability Measures

Predication Time		Predicability Rating
Word	**Mean**	**Mean**
Moral	41.63(12.96)	3.10(1.55)
Snore	31.83(10.50)	5.10(1.65)
Chlorine	25.49(7.41)	4.65(1.78)
Painting	30.22(8.18)	5.75(1.41)
Football	26.85(6.82)	6.45(0.82)
Worth	49.52(34.78)	2.80(1.73)
Satin	25.25(6.66)	5.25(1.71)
Laughter	32.56(8.75)	4.25(1.77)
Greed	50.02(26.38)	3.65(1.46)
Curry	24.83(7.13)	6.25(1.20)
House	24.96(7.33)	6.95(0.22)
Wool	22.46(5.93)	6.20(0.89)
Choir	30.43(10.37)	5.70(1.30)
Pump	11.27(2.52)	5.40(1.14)
Can opener	30.43(10.37)	5.75(1.37)
Cry	29.03(10.25)	4.85(1.81)
Cheese	23.08(7.52)	6.75(0.55)
Wisdom	35.47(11.59)	3.45(1.76)
Axe	27.25(11.48)	6.20(1.05)
Butterfly	32.16(18.8)	6.70(0.57)
Spade	26.99(8.92)	6.15(1.08)
Thunder	30.82(9.85)	5.25(1.91)
Coffee	23.40(7.32)	6.20(1.24)
Cloud	24.33(5.91)	6.10(1.02)
Hammer	28.62(9.21)	6.25(1.07)

Ice	19.52(9.31)	6.30(1.03)
Mountain	28.66(9.98)	6.25(0.78)
Thought	45.50(28.69)	4.45(1.57)
Sponge	25.52(8.50)	5.70(1.34)
Smoke	27.51(9.52)	5.20(1.60)
Whistle	39.96(27.70)	5.65(1.56)
Racquet	32.21(13.67)	6.05(1.14)
Attitude	44.35(30.44)	3.25(1.80)
Needle	25.86(10.79)	6.05(0.88)
Rose	19.90(7.37)	6.70(0.57)
Fire	22.35(11.89)	6.15(0.93)

Chapter 6 Experiment 4.

Sentences used in the test phase with positive, negative, and neutral cues

Positive.

1.Try to think of a situation in the future where you are laughing

2.Try to think of a situation in the future where you feel friendly

3. Try to think of a situation in the future where you feel proud

4. Try to think of a situation in the future where you feel relaxed

5. Try to think of a situation in the future where you feel helpful

6. Try to think of a situation in the future where you feel enthusiastic about something

Negative cues

1. Try to think of a situation in the future where you have an argument with someone

2. Try to think of a situation in the future where you feel a failure

3. Try to think of a situation in the future where you feel lonely

4. Try to think of a situation in the future where you feel embarassed

5. Try to think of a situation in the future where you may get blamed for something

6. Try to think of a situation in the future where you feel nervous

Appendix C

Neutral cues

1. Try to think of a situation in the future where you are having a conversation with someone
2. Try to think of a situation in the future where you will be browsing around a shop
3. Try to think of a situation in the future where will either give or receive advice
4. Try to think of a situation in the future where you will receive a package
5. Try to think of a situation in the future where you are travelling somewhere
6. Try to think of a situation in the future where you will listen to music.

Appendix D

Calculation of Evans' Randomization Index.

A randomization matrix is used in the calculation of this index where the responses are tabulated in a 10 by 10 matrix. The matrix is arranged to reflect the frequency with which any number follows any other number in the 100 consecutive responses. In a random sequence of 100 responses, each of the 10 numbers would theoretically follow each other number only once. It is this frequent usage of repeated pairs of sequences (such as "9,4","9,5", "9,1" in the example) which builds up the value of the randomization index, calculated using the formula presented below. Following the tabulation of all such pairwise sequences marginal frequencies are determined by summation.

Formula for RNG

The formula for the index of randomization after Tulving (1962) is

RNG = the sum of (fij) times log (fij) /by the sum of (fi) times
log (fi)

The numerator is a function of the sum of the log of all Cell (ij) frequencies; the denominator is a correction factor necessary when the obtained distribution of marginal cell frequencies deviates from (random) 10. The randomization index reflects the disproportion of sequence pairs within the cells adjusted by the disproportion of the marginal cell frequencies. It has a range of values from 0.0 to 1.0 and a higher index reflects more extreme departure from the theoretical expected values that is, it indicates poorer randomizatio.