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The Effect of Imageability and Predicability of Cues in Autobiographical Memory

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Four experiments investigated the role of imagery in the recollection of autobiographical memories. The first two experiments examined the effects of word imageability and word frequency on the retrieval of personal memories in a cued autobiographical memory task. They showed that the imageability of cues (but not frequency) mediates specificity in the recall of personal memories. Experiment 2 explored how different imagery modalities (visual, olfactory, tactile, auditory, and motor) influence autobiographical retrieval. Consistent with research on imagery modalities in verbal learning paradigms, visual imageability emerged as the most significant predictor of specificity. Experiments 3 and 4 examined how far a knowledge-based account of imagery effects might account for these effects, using predicability as a measure of semantic richness of a cue. Results found that visual imageability of cues accounted for more variance in specificity of recall than did predicability. The results are explained in terms of the way images represent the most efficient form of summarizing the information that can be used at each stage of the recollection process: setting the retrieval plan, strategic search, and evaluation of candidate episodes.

We are interested in the role that imagery plays in autobiographical memory. Its role in other domains of memory has been well documented, with most early work focusing on the importance of concrete versus abstract materials in traditional verbal learning paradigms and on the organizational factors in memory (Paivio, 1971, 1986; Paivio, Yuille, & Madigan, 1968). It is only recently that research has begun to explore imagery effects in personal event memory. For example, imagery is said to play a critical role in source monitoring: Memories for real experiences are richer in sensory details and contextual attributes than are memories for imagined experiences (Johnson, Hashtroudi, & Lindsay, 1993). The ability to discriminate between both types of event increases with the degree of sensory-perceptual information contained in memories for real events (Johnson, Foley, Suengas, & Raye, 1988; McGinnis & Roberts, 1996). Similarly, Dewhurst and Conway (1994) suggest that encoding conditions involving sensory-perceptual and semantic processing subsequently enhance recognition memory.

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Brewer (1988) used a random alarm device to study randomly sampled events from the lives of naive subjects and subsequently used a cued recall technique to test memory. The overall results show that correct autobiographical recall almost always involves high visual imagery. Other authors have found similar results, for example De Beni and Pazzaglia (1995) identified three different categories of images in memory: general, specific, and autobiographical. In addition, Conway (1988) using an image generation task showed that autobiographical memories were higher in vividness than were semantic images. All the above studies suggest that the sensory perceptual code is a rich source of recollective experience.

Johnson (1992) suggests that recollection is composed of three related processes: the mechanisms by which cues access memory traces (associative search), the mechanisms by which aspects of a memory (e.g. specificity) become associated in memory, and the mechanisms by which personal recollections are judged to be accurate accounts (source monitoring). Johnson's Multiple Entry Memory (MEM) System (Johnson & Hirst, 1993) distinguishes between two lower level perceptual subsystems designed to extract information from the environment and two reflective subsystems that have the capability of supervision, monitoring and executive control. Johnson and Hirst (1993) suggest that reflective mechanisms are involved in source judgements necessary for episodic memory. In MEM, the sense of "remembering" and "knowing" reflect the attribution made on the basis of the subjective quality of the memory experience. According to MEM the maintenance, over time, of contextual or perceptual detail is critically dependent on the subprocess called "reactivation". It is disruption of this subprocess that gives rise to the lack of specificity in recollection. The evidence reviewed earlier suggests that the "reactivation" subprocess is heavily dependent upon imagery. The question remains, however, as to how these beneficial effects of imagery upon remembering come about. This paper examines what aspects of imageability mediate the retrieval power of cues in the recollection of personal memories, focusing on the specificity of those memories retrieved.

Previous research examining the effect of imagery on autobiographical memory has used as dependent variables of interest the speed of retrieval of events (Conway, 1987) or their match to real events (Johnson et al., 1988) or the relative probability of recall (Brewer, 1988). The way in which imagery has its effects on these outcomes is inferred rather than observed, because the dependent variables yield quantitative differences (e.g. in latency or probability) of the same type of event. For example, latency to recall events might be used as the dependent variable to infer the usefulness of different cues such as activities ("going to the cinema") versus general actions ("finding a seat"). However, a growing number of studies in autobiographical memory have moved away from seeing the single "event" as the main unit of analysis, attempting instead to understand variations that occur in the nature of the recall protocols themselves, or in the errors made when individuals try to retrieve events from their past. This variability in retrieval output is seen most clearly in clinical groups (see later) but also occurs in normal participants, and it has most often been understood as the result of the way autobiographical memories (or retrieval processes) are organized.

Evidence suggests that autobiographical recollection is best viewed as retrieval from within a hierarchy of nested events in which individuals move with varying degrees of

fluency between different levels of the hierarchy. A number of independent studies support the notion that autobiographical memory is hierarchically organized (Conway, 1992; Conway & Bekerian, 1987; Linton, 1986; Schooler & Hermann, 1992). Thus the construction of autobiographical memories depends upon access to an autobiographical knowledge base, and each layer of autobiographical knowledge, organized in an hierarchical fashion, provides indices to the other levels and thus facilitates access (Barsalou, 1988; Conway & Bekerian, 1987; Williams, 1996; Williams & Dritschel, 1988). Retrieval of specific memories is mediated by a cyclical strategic series of events. Three distinct steps proposed by Williams and Hollan (1981) are "find a context", "search", and "verify". Consider how these steps are implemented when participants are given a cue such as "mountain" to direct the memory search. Typically this cue acts as a partial descriptor (Norman & Bobrow, 1979) and activates contextual search cycles such as "times I have climbed Snowdon" or "skiing in France". Such thematic instances provide the appropriate general event for a relatively coarse-grained specification of the TBR (To Be Remembered) material. It is then repeatedly sampled until a more specific memory fulfilling the target criteria is found, such as "climbing Snowdon on a hot sunny day with my family". Verification of memory output confirms that a candidate memory does indeed satisfy experimental constraints. Thus subjects typically generate a specific memory by firstly accessing an extended or general event theme—"that first summer in Wales"—and the cycle proceeds by a progressive narrowing onto specific events and episodes. By using cue methodology, a number of discrete memory responses can be obtained and analysed for the extent to which they represent outputs from different "levels" of such nested hierarchies. The effect of varying imagery can then be studied by examining the extent to which varying the imageability of a cue facilitates or impairs the fluency with which a person moves through the hierarchy.

Why is this important? It is because patients with frontal lobe impairments (see Baddeley & Wilson, 1986; Crovitz, 1986) and patients with emotional problems such as depression (see Williams & Scott, 1988) or post traumatic stress disorder (McNally, Litz, Prassas, Shin, & Weathers, 1994) show characteristic dysfluencies in accessing specific memories. That is, when attempting strategically to recall events, patients respond with generic "categories" (such as "when I used to play squash") and fail to access a specific, context-bound event memory (such as "when I played squash last month with Ben"). It appears they truncate the memory search at the level of intermediate "descriptions" (Norman & Bobrow, 1979; Williams, 1996), and fail to use the descriptions to generate a specific exemplar. These dysfluencies have been found to be significant clinically in that they reduce problem-solving ability, and impair a person's ability to imagine the future (Evans, Williams, O'Loughlin, & Howells, 1992; Goddard, Dritschel, & Burton, 1996; Williams, Ellis, Tyers, Healy, Rose, & MacLeod, 1996). Yet little is known about how this deficit comes about. One possibility is that individuals cannot use mnemonic cues effectively to search memory. If so, one should be able to analogize such categoric retrieval by varying the "goodness" of the cue. On the basis of the foregoing argument, it seemed likely that the imageability of the cue was the most likely candidate for mediating the ability to retrieve specific memories.

Other evidence suggesting that imageability and retrieval processes are closely linked comes from neuropsychological studies. Ogden (1993) has suggested that failure to

activate visual imagery processes contributed to the retrograde amnesia demonstrated by his patient MH. O'Connor, Butters, Miliotis, Eslinger, and Cermak (1992) describe a patient LD who exhibited severe retrograde amnesia, mild anterograde amnesia, and visual object agnosia. The visual agnosia resulted in poor performance on visuo-spatial tasks, and these deficits were largely attributed to disruptions in visual imagery function. Although verbal processes with this patient remained relatively intact, and she retained a certain amount of semantic and personal knowledge, she could not remember any specific memories that predated her illness. O'Connor et al. proposed that this patient's visual agnosia contributed significantly to the semantic/ episodic dissociation seen in her retrograde amnesia and that in addition intact verbal processes facilitated and maintained knowledge that was largely factual and semantic in nature. The ability to generate visual images would appear to be necessary to transform a personal fact "I live near the sea" to a specific memory for events relating to that knowledge—"sailing with my friends last August".

Protocols provided by non-clinical participants indicate that information in images can be elaborated upon in order to access further information related to an event (Whitten & Leonard, 1981). If images do contain information that 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). We suggest that imagery affects autobiographical memory primarily via the different nested partonomies that constitute hierarchical or structural models. We assumed (see also Conway, 1988) that images represent summary information in autobiographical memory, which can be used to direct memory searches; they contain information that is richly informative about a represented event in the sense that information in the image facilitates access to other related events and themes. Thus the information contained in an image may be employed as a source of powerful cues by retrieval process with which to probe memory traces (Marschark, Richman, Yuille, & Reed Hunt, 1987; Marschark & Surian, 1989). A cue word high in imageability makes more probable 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 direct the retrieval cycle. In summary, using a hierarchical model as a possible substrate for imagery effects enables us to make predictions about the type of memory output that will be associated with varying levels of imageability. High-imageable cues will result in more specific memory; low-imageable cues will produce more general, categoric memories.

The aim of these studies is to examine the role of imagery in the retrieval of autobiographical memories. The first experiment examines the effect of varying the imageability of cue words on the specificity of autobiographical memory retrieval. In addition, it varies the frequency of the cue word to check that generic memories are not simply the result of failure to distinguish between common events. For example, the cue word "breakfast" might yield less specific memories simply because it is a high-frequency event for many people, with few features distinguishing one event from another. By contrast, a less frequent cue such as "concert" might result in a more specific memory simply as a result of its greater distinctiveness; there having been fewer concerts in a person's life than breakfasts. Finally, we examine the age of the memories recalled to see whether high-imageable words cue more remote events (given the high correlation between imageability and age of acquisition; $r = -.72$, in Gilhooly & Logie, 1980).

We report a clear effect of imageability (and no effect of frequency) on the specificity of autobiographical recall, which is not mediated by the remoteness or recency of the event recalled.

But what sort of imageability? Past studies of verbal learning have found that visual imageability is the main mediator of memory effects (Ellis, 1991). The second experiment explores the role of different imagery modalities in the retrieval of personal event memories, finding that, analogous to verbal learning, visual imageability is the most powerful mediator of specificity of retrieval in autobiographical memory. Jones (1985, 1988) introduced a specific knowledge-based alternative to the notion of imageability. 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. This alternative account of imagery is explored in Experiments 3 and 4.

It has been suggested many times that the process of retrieving information along links in a memory network is affected by the internal structure of those representations. For example, De Groot (1989) using a word association task showed that word imageability exerts a strong influence on word association whereas the effect of word frequency was not significant. Using an *m* score—a measure of the number of responses generated within a pre-specified amount of time in a word association task (Noble, 1952)—they obtained larger *m* scores for concrete words than for abstract words (De Groot, 1989). These findings suggest that the concept nodes for concrete words contain more information than those for abstract words. Similarly Kieras (1978) suggested that the imagery effects result from high-imageable words being different from low-imagery words purely on semantic attributes. In our third and fourth experiment we examine the possibility that it is the semantic richness of high-imageability cues that most helps the rapid generation of intermediate descriptions and their subsequent use in the search for specific exemplars.

EXPERIMENT 1

Method

Subjects

Twenty-four participants consisting of 20 females and 4 males were recruited from the Undergraduate Subject Panel of the University of Wales, Department of Psychology. The mean age of participants was 30 years, (SD = 9.4; range = 21–48).

Materials

The test materials consisted of 32 cue words selected from Paivio et al.'s (1968) corpus of 925 nouns from which high and low imageability ratings were taken. Francis and Kucera (1982) frequency ratings were obtained for each cue word. Word imageability (high vs. low) and word frequency (high vs. low) were orthogonally varied in this design. Each of the four stimulus groups consisted by the two levels of each of these two variables (imageability and frequency) consisted of eight words. In order to check whether written frequency for cue words matched spoken frequency, spoken frequency norms were taken from frequency ratings extracted from CELEX Psychology Linguistic Database Release 2. These ratings matched written frequency norms. To ensure that all

cues used were comparable in terms of familiarity, ratings of all cues on this variable were taken from the MRC database. There was no difference between high- and low-imageable cue words in terms of their familiarity (familiarity ratings = 537.1 and 538.2 for high- and low-imageable cues, respectively). Familiarity ratings did map onto frequency ratings with high-frequency cues yielding a familiarity rating of 573.5, versus 501.9 for low-frequency cues. Mean imageability, familiarity, and spoken and written frequency ratings for cue words are shown in Table 1.

Procedure

Autobiographical Memory Task. The task requires participants to retrieve a specific memory as quickly as possible in response to a cue word. A specific memory is explained to the participant in terms of a past experience that happened on a particular day in a particular place, which could be readily dated. The following instructions were given to all respondents:

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 a part last Monday in the Student Union''.

The presentation of each cue word was alternated across cue categories varying in frequency and imageability, and the time taken to respond to each cue was recorded by a stopwatch. If no response was made after 30 sec, a time of 30 sec was recorded and the next item presented. A memory was deemed specific if the participant recalled an event referring to one particular day. The criterion of an experience that lasts more than 1 day or less than 1 day has been used frequently to define a specific memory (e.g. Williams & Dritschel, 1992).[1]

Following completion of this task, subjects were then requested to rate their memories for vividness, memory specificity, and whether the memory was pleasant or unpleasant, and to date approximately 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 used for pleasantness ratings. For subjective 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

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 scored 1 point, and omissions scored 0. A memory was deemed specific if the participant recalled a particular event that lasted one day or less. Consider a typical response to the cue *lake*; ''that reminds me of holidays in Scotland [categoric memory]; spending last summer there [extended memory] collecting mussels by the lake one hot Sunday afternoon [specific memory].'' Such a protocol reflects the hierarchical structure of autobiographical memory and the progressive narrowing of search processes adopted in strategic retrieval. A subsample of responses was rated by an independent

[1] A ''no cue'' condition was included in this study because, in the absence of a cue, it would not be possible to control for the range of possible self-cueing procedures that participants might use.

TABLE 1
Mean Imageability, Familiarity, and Spoken and Written Frequency Ratings of Cues

	Imagery							
	High				*Low*			
Frequency	*Imag*	*Freq. S*	*Freq. W*	*Fam.*	*Imag*	*Freq. S*	*Freq. W*	*Fam.*
High	6.4	106	98.5	581.87	5.84	171.50	224.87	565.12
	(0.37)	(110.3)	(76.14)	(23.15)	(0.96)	(146.9)	(126.28)	(14.85)
Low	3.3	14.75	19.4	492.37	3.3	17.50	32.75	511.37
	(0.38)	(25.86)	(29.9)	(38.63)	(0.38)	(16.44)	(21.52)	(57.60)

Imag. = imagery; Freq. S = spoken frequency; Freq. W = written frequency; Fam. = familiarity; Ratings. Standard deviations in parentheses.

second rater and inter-rater reliability was 85%. For each subject, the mean specificity score of responses 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) $\times$ 2 (frequency) $\times$ Subjects analysis of variance (ANOVA) was performed on the mean memory specificity scores and mean retrieval times, treating imageability and frequency as within-subject variables.[2]

The corresponding 2 $\times$ 2 $\times$ 8 (stimulus words) ANOVA was also performed treating imageability and frequency as between item variables. A series of ANOVA's were computed on mean specificity scores, mean retrieval scores, and also on response omissions or the number of times participants failed to respond to a cue word. The results of all the above analyses are reported using F_1 to denote subject analyses and F_2 to denote item analysis.

Memory Specificity

The means and standard deviations of specificity scores are shown in Table 2. A main effect of imageability was significant on both the memory specificity analyses, $F_1(1, 23) = 44.48$, $MSe = 9.60$, $p < .001$, and $F_2(1, 28) = 14.88$, $MSe = 2.00$, $p < .001$. The mean specificity score of memories retrieved was 2.4 and 2.0 for combined high- and low-imageable cues, respectively. There was no main effect of frequency in either item analysis or subject analysis. Fs < 1. No significant interaction was found, $F < 1$.

[2] No attempt was made to verify the accuracy of memories retrieved by participants. All cue words used in the reported studies were neutral cues and thus unlikely to be subject to strategic biases or confabulations. Other studies (e.g. Brewer, 1988) find participants are accurate in their recall of such material. Occasionally dates are misremembered or some details forgotten. However, such errors should not affect the main variable of interest here, which is the specificity of the retrieval output.

TABLE 2
Mean Retrieval Time and Mean Specificity Score for all Imageability × Frequency Conditions

	Imageability			
	High		*Low*	
Frequency	*RT*	*SS*	*RT*	*SS*
High	6.67 (1.6)	2.42 (0.30)	11.11 (2.0)	2.02 (0.29)
Low	6.98 (1.2)	2.35 (0.23)	11.42 (2.6)	2.03 (0.08)

RT refers to retrieval or latency time to recall the first word of an event, SS refers to the mean specificity score. Standard deviations in parentheses. Mean retrieval time in seconds.

Mean Retrieval Times

The means and standard deviations of the retrieval times for specific memories are shown in Table 2. A main effect of imageability was significant for the mean retrieval time to respond to stimulus cues, $F_1(1, 23) = 40.89$, $MSE = 11.51$, $p < .001$, $F_2(1, 28) = 41.11$, $MSE = 3.83$, $p < .001$. The mean retrieval time to respond was 6.70 sec and 11.27 sec for combined high- and low-imageable cues, respectively. The main effect of frequency was not significant for either item analysis or subject analysis, Fs < 1. No significant interaction was found, $F < 1$.

Omission Scores

The omission scores (where participants failed to respond to a particular cue word) were analysed in a 2 (frequency, high and low) × 2 (imageability, high and low) ANOVA. The main effect of imageability was significant, $F_1(1, 23) = 11.52$, $MSE = 0.66$, $p < .01$; $F_2(1, 28) = 16.40$, $MSE = 1.38$, $p < .01$. A greater number of omissions were produced in response to low-imageable stimuli (2.06) than to high-imageable stimuli (0.38). Neither the frequency main effects nor interactions were significant Fs < 1.

Subject Ratings

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. These rating scores are shown in Table 3. Three 2 (imageability, high and low) × 2 (frequency, high and low) ANOVAs were computed. Imageability and frequency were treated as within-subject factors. For subjective ratings of 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 Fs < 1. 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

TABLE 3
Participants' Ratings of Vividness, Pleasantness, and Mean Specificity for All Imageability × 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.

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 cue 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, $F(1, 23) = 19.90$, $MSE = 0.16$, $p < .001$. Simple effects of contrasts 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 high-frequency–high-imageability cues were significantly more pleasant than those retrieved to high-frequency–low-imageability cues, $p < .001$, and no significant differences were shown between high-frequency–high-imageability cues and low-frequency–high imageability cue words.

Age of Memories

The ages of the memories retrieved by participants were standardized following Conway's (1987) procedure. 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 was 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 standardized 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. Neither main effects nor interactions were significant, Fs < 1 in all cases; there were no significant differences in the ages of memories retrieved to the different cue groups. The mean ages of memories retrieved for high-frequency–high imageability,

high-frequency–low-imageability, low-frequency–high-imageability, and low-frequency–low-imageability cues were all recent memories with mean ages of 0.89, 0.83, 0.88, and 0.86, respectively.

Discussion

The aim of this experiment was to assess the effects of cue word imageability and word frequency on both the quantitative and the qualitative aspects of the retrieval in autobiographical memory. Although previous studies had suggested that imagery may facilitate the retrieval of information from memory it was unclear how it would affect retrieval searches through the hierarchical structures of autobiographical memory. The results showed that words high in imageability aid the retrieval of more specific memories.

Although retrieval times for autobiographical memory recall are commonly very labile, cue words high in imageability resulted in greatly reduced retrieval times compared to low-imageable cues. This difference in latency was not due to high-imageable cues accessing recent events. The ages of specific memories retrieved to the different cues were all relatively recent memories, and no differences were found between the ages of memories retrieved to the different cue types.

There was no significant effect of word frequency on the specificity of memory responses or on the mean memory retrieval times. Frequency of a cue appears not to affect its ability to facilitate search through the memory hierarchy. Spoken and written frequencies of cues were comparable, and as familiarity of cues used in this study were matched with frequency ratings, it appears that cue familiarity did not contribute to memory search. So long as a cue generates a clear and discriminable image, it does not matter if the event represented is frequent (e.g. *breakfast*) or infrequent (e.g. *concert*). This is consistent 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 suggested that word imageability exerts a strong influence on word association, whereas the effect of word frequency is negligible. Unlike the referents of abstract words, the referents of concrete words have shapes, colours, and physical parts, and occur in spatial contiguity with other objects. When a subject is presented with a cue word and required to evoke a specific personal memory in response, the characteristics of highly imageable words may facilitate the retrieval of specific event memories by providing multiple access routes to intermediate pathways in the autobiographical memory hierarchy.

However, imagery varies across a number of different dimensions or modalities. The question arises as to whether a particular form of imagery is more closely associated with the retrieval of specific autobiographical memories. Although 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 also have a functional role. Although Baddeley and Hitch (1974) proposed only two slave systems (the visuo spatial sketch pad and the phonological loop) in their model of working memory, it was recognized that there may be other slave systems with specialized functions, for example tactile, kinaesthetic, or olfactory.

Ellis (1991) investigated the effects of visual, auditory, olfactory, motor, and touch imagery on lexical meaning and memory. Although there were clear effects of the visual imageability of words on free recall after intentional learning, paired-associate learning, and amount of Stroop interference, there were no effects of the other imagery dimensions. Of the range of perceptual modalities, it was imageability in vision alone that afforded greater meaningfulness, more attributes, a larger number of associates regarded as being similar, and a greater number of associations present in any episode of an image experience. Ellis (1991) argued that the rich associations afforded by vision underpin the effects of visual imagery on lexical memory and meaning. Do these same processes affect autobiographical memory retrieval? The role of these different imagery modalities has not been investigated previously in autobiographical memory. The aim of the next study is to use cues varying across a number of imagery dimensions to see if visual imageability emerges as the most significant predictor of memory specificity.

EXPERIMENT 2

Method

Subjects

Twenty-four participants took part in this experiment. They were all psychology undergraduates. There were 15 females and 9 males. The mean age of the sample group was 23.6 years (SD = 6.13 years; range 19–38 years).

Materials and Procedure

A cue word paradigm was employed. Word norms for imageability in visual, auditory, olfactory, motor, and tactile modalities were taken from Ellis (1991). Six 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 from each list and an additional six abstract words having low ratings on all perceptual modalities were selected. 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 mean modality ratings for all these cues are shown in Table 4.

The procedure followed was similar to that in Experiment 1. Each participant was presented with 36 cue words with instructions to recall a specific event to each cue word. The cue words reflected different word imagery modalities, and the presentation of words was alternated across modality for all autobiographical memory trials. 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.

Although the cue words were sampled to try to maximize orthogonality between the different modality ratings, in fact this proved impossible to achieve. In Table 4 it is clear that olfactory, tactile, and motor words tend to be high on the visual imageability dimension. As reported later, the correlation between visual and tactile imageability is .52 and that between visual and olfactory imageability is .54. For this reason we do not report between-modality ANOVA's, which assume orthogonality between the different word sets. Rather, we report correlational analyses followed by multiple regression.

TABLE 4
Mean Modality Ratings for Word Norms

Modality	*Vis.*	*Olf.*	*Tac.*	*Aud.*	*Mot.*
Visual	*5.80*	1.98	2.71	1.77	4.00
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.

Results

A correlation matrix (see Table 5) was computed between the five sensory modality ratings, cue frequency, memory specificity, mean retrieval times, and memory ratings. Memory specificity correlated significantly with cue words high in visual imagery, $r(36) = .53$, $p < .01$, and in motor imagery, $r(36) = .49$, $p < .01$. A negative significant correlation, $r(36) = -.67$, $p < .001$, was shown between memory specificity and the mean latency to retrieve a specific memory.

Cue words high in visual imageability also correlated significantly with ratings for mean pleasantness, $r(36) = .40$, $p < .05$, and mean vividness, $r(36) = .52$, $p < .01$. Memory specificity also correlated significantly with mean self-noted vividness of the memory recalled, $r(36) = .86$, $p < .001$.

In order to determine the contributions of different imagery modalities to the variance associated with specificity in autobiographical memory, multiple regression analyses were performed using memory specificity and mean retrieval time as the dependent variables.

TABLE 5
Pearson Correlation Coefficients 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 subjective vividness, MP = mean subjective pleasantness, MF = mean subjective frequency of rehearsal, significant correlations in italics, $p < .01$.

The total number of specific memories retrieved by participants in the sample group to each cue word (maximum = 24) was the dependent variable. The independent predictor variables included the five sensory modalities (visual, auditory, tactile, motor, and olfactory) for each word. When all these variables were entered simultaneously into a multiple regression equation, the only significant predictor was visual imageability ratings, $\beta = .59$, $p < .01$. This predictor accounted for 51% of the variance. A stepwise regression where memory specificity was the dependent variable stopped after two blocks when the only significant predictors entered were visual and auditory imagery, $\beta = .66$, $p < .01$ for visual imageability, and $\beta = .52$, $p < .01$ for auditory imageability. Visual imageability contributed 28% and auditory imagery 17% of the variance in memory specificity at the second step of this model.

The same multiple regression analyses were performed with mean retrieval times as the dependent variable. Visual imagery was a significant predictor, $\beta = -.67$, $p < .01$, and also auditory imagery $\beta = -.44$, $p < .05$, 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, $\beta = -.73$, $p < .01$ and auditory imageability, $\beta = -.49$, $p < .01$, with each variable contributing 35% and 22% of the variance, respectively. The results of the multiple regression analysis suggest that visual and auditory imagery are the only sensory modalities that contribute significantly to the variance in both dependent variables (specificity and speed of retrieval in autobiographical memory).

Discussion

Although the results of Experiment 1 showed that participants found it more difficult to retrieve a specific memory in response to a low-imageable cue word, 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. Multiple regression analyses showed that both visual imageability and to a lesser extent auditory imageability were significant predictors of both memory specificity and mean retrieval time.

This finding extends previous work by Ellis (1991), who investigated different sensory modalities for their effect in determining free recall and paired associate learning performance. Similar to the results of this experiment, he found that the most significant contribution was that of visual imageability. This occurred across all such tasks. The result was attributed to both the visual parallelism and the coding richness afforded by the visual system: The rich representations of items and cues mediated by visual imageability allows a greater number of meaningful associative linkages. Extending these findings to the case of autobiographical recall, we suggest that it is the way visual images enhance contextually rich retrieval cycles that results in speedy access to more specific memories. Visual parallelism implies that activation of the visual codes initiates activation in semantic and episodic systems, resulting in wide-spreading activation of all possible inter-relations.

Although visual imageability is the most significant factor facilitating fluency in the retrieval of specific autobiographical memories, auditory imagery also contributes 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 there is less evidence for its involvement in evoking and experiencing images of this kind (Baddeley & Logie, 1992).

Although the results of this study suggest that auditory imagery effects might map onto the non-visual component of working memory, the independence of that role remains unclear given that all cues high in auditory imagery were presented orally. This finding needs replication to explicate fully the role of auditory imagery and the phonological loop in the retrieval of autobiographical memories. However, there is preliminary evidence from other studies of links between visual and auditory cueing. In a study described by Intones-Peterson (1992), when participants were asked to generate an auditory image of a commonly experienced event they also generated a visual image. This was a pronounced effect, with visual images being generated to 95% of phrases. This effect is likely to be due to between-modality imaginal facilitation, which occurs when an object elicits an image in more than one modality. Sometimes the visual image preceded the auditory one—for example, given the cue ''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, although visual images and auditory images are clearly related, visual imagery appears to have primacy over auditory imagery in the recollection of specific autobiographical events, as it does in these between-modality imagery experiments.

The use of high- and low-imageable cues in Experiments 1 and 2 has successfully enabled us to manipulate the retrieval of autobiographical memories. Strategic retrieval of specific autobiographical memories is enhanced by cue words high in visual imageability. Low-imageable cues are more effortful in terms of constructing a context that 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. How could such a knowledge-based account of imagery effects be investigated? One way is to make use of a predicability measure proposed by Jones (1985, 1988) and to examine its effect on the retrieval power of cues used in autobiographical memory tasks.

The predicability of a word is 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 generated and the ease with which images of those same words can be formed. Thus a cue word high in predicability may facilitate 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 that 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 strategic 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 two experiments that result in the production of more general memories.

EXPERIMENT 3

The purpose of this experiment was to obtain predicability measures on cue words used in the first two experiments with a view to examining the predictive power of such a measure. A total of 68 cue words were examined. Group A consisted of 32 cue words used in the first experiment. Group B (36 words) were taken from word norms used in Experiment 2. Following Jones (1985, 1988) both subjective and objective ratings of word predicability were obtained. The subjective ratings involved subjects rating individual cue words. The objective measure required participants to generate and write down two factual statements to the cue words as rapidly as possible.

Method

Subjects

Forty psychology undergraduates from the University of Wales Bangor were recruited from the student subject panel as part fulfilment of course credits. Of these, 20 participants (11 males and 9 females) with a mean age of 33 years completed an objective predicability task, and, the remaining 20 subjects (13 females, 7 males) with a mean age of 28 years completed the subjective ratings. This process was employed to avoid possible confounds if the same participants performed both tasks.

Procedure

Subjective Predicability Rating. Each subject rated a set of 68 nouns. The words were presented in randomized order and were arranged on successive pages of a booklet. The numerals 1 to 7 were printed with 1 and 7 representing the 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 categorize) 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.

Objective Predicability Measure. The objective predicability task was completed by a different group of participants. Predication time was the time taken (in seconds) to generate two statements for each word. The instructions similar to those used by Jones (1985) 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 "horse" would probably be judged as very easy to make simple factual statements about because it can readily be put into statements. For example "A horse is a type of animal" and "A horse often lives in a stable". The factual statements must refer to the word concerned and not just contain it. What you have to do is to 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.

This procedure was followed for each trial, and a stopwatch was used to collect timings for each set of predicates generated. Timing commenced when participants said "Now" and ended with the tap sound.

Results

Predicability measures (both objective and subjective) were analysed for the cue words used in Experiment 1. Paivio et al.'s (1968) 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 6. All correlations were significant, $p < .001$. Predication time and predicability ratings for all cues (Group A) used in Experiment 1 correlated significantly with imageability, $r(32) = -.74$, $p < .001$, and $r(32) = .74$, $p < .001$, respectively. Specificity in autobiographical memory retrieval was also significantly correlated with predication time and predicability ratings $r(32) = -.68$, $p < .001$, and $r(32) = .63$, $p < .001$, respectively.

Both objective and subjective predicability measures for cue words (Group B) used in Experiment 2 were also analysed. Paivio imageability ratings were not available for this group of words, so visual imageability ratings from the word norms used in Experiment 2 were used for all analyses. Pearson's correlation coefficients between these ratings and memory specificity and imageability scores were computed (Table 7).

These correlations replicated the results obtained with cues used in Experiment 1. A significant correlation was found between visual imageability and predicability ratings, $r(36) = .84$, $p < .001$, and between imageability and predication time, $r(36) = -.67$, $p < .001$. Predication time and predicability ratings were correlated with the specificity of memory, $r(36) = -.66$, $p < .001$, and $r(36) = .52$, $p < .001$, respectively, with higher predicability rating and predication fluency being associated with more specific event

TABLE 6
Imageability, Predicability, and Autobiographical Memory Measures of Cues Used in Experiment 1

	P.Time	*P.Rating*	*Paivio's I.*	*Specificity*	*MRT*
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
MRT					1

P.Time = predication time, P.Rating = predicability rating, Paivio's I. = Paivio's imageability, Specificity = memory specificity, MRT = mean retrieval time. All correlations significant, $p < .001$.

TABLE 7
Imageability, Predictability, and Autobiographical Memory Measures of Cues Used in Experiment 2

	P.Time	*P.Rating*	*Visual I.*	*Specificity*	*MRT*
P.Time	1	−0.69	−0.67	−0.66	0.60
P.Rating		1	0.84	0.52	−0.69
Visual I.			1	0.53	−0.59
Specificity				1	−0.67
MRT					1

P.Time = predication time, P.Rating = predicability rating, Visual I. = visual imageability, Specificity = memory specificity, MRT = mean retrieval time. All correlations significant, $p < .001$.

memory. There was also a significant correlation between predication time and mean retrieval time for those words, $r(36) = .60$, $p < .001$. Given the high correlation between predicability ratings and visual imageability there would appear to be very little difference between the variables in terms of their association with specificity in autobiographical memory. The high collinearity between predicability and imageability precluded the use of multiple regression techniques. Experiment 4 attempts to separate these two variables in order to reduce collinearity, so that individual contributions of each to memory specificity might be examined.

EXPERIMENT 4

The aim of this final experiment is to examine further the predictive power of cue words that vary across the dimensions of predicability and visual imageability. Because the previous experiment has demonstrated that both imageability and predicability are highly related, it is necessary to derive a set of cue words in which both variables are separated as much as possible, in order to examine the individual contributions of each parameter to specificity in autobiographical memory.

Method

Subjects

19 participants (17 females and 2 males) took part in this experiment as part fulfilment for course credits. The mean age was 24.4 years and all participants were psychology undergraduates from the University of Wales, Bangor.

Design

A within subject analysis was used with cue condition as the within-subjects variable. Two sets of cue words were derived, and all subjects were given a total of 40 cue words in the standard autobiographical memory task where memory specificity was the dependent variable.

Procedure

Ease of predication measures were obtained from a large 144-word set collected as part of another study. Two word sets were selected: Set A consisted of 20 words where visual imageability ratings were kept relatively constant and predication measures were allowed to vary; Set B consisted of 20 words where predication measures were kept relatively constant and visual imageability measures were allowed to vary. Pearson's correlation coefficient between imagery and predication variables confirmed that this selection of words had reduced the correlation between predicability and imageability variables to non-significant levels, making the use of multiple regression techniques possible: Set A, $r(20) = .17$, $p > .05$; Set B, $r(20) = .20$, $p > .05$.

All participants were given both word sets in the standard autobiographical memory task. The order of presentation of cues was randomized for each subject; half of the subjects received Set A first followed by Set B, and the remainder received Set B followed by Set A. Participants were requested to retrieve a specific memory in response to a cue word as in the previous two experiments. Practice trials were given, and the time taken to retrieve a specific memory was recorded. The maximum time given to retrieve a memory was 30 sec, and if participants failed to retrieve a memory within this time frame, the following cue word was given. Memories were then scored, and a mean specificity score was calculated for each word across the 19 participants with a mean retrieval time.

Results and Discussion

Word sets were analysed separately. For Set A with restricted visual imageability ratings and variable ease of predication, Pearson correlation coefficients with memory specificity were not significant for either (restricted) visual imageability scores, $r(20) = .15$, $p > .05$, or ease of predication scores, $r(20) = .15$, $p > .05$. This suggests that when visual imageability is restricted, variation in predicability does not contribute to the retrieval of specific autobiographical memories.

By contrast, for Set B where ease of predication measures were restricted and the corresponding visual imageability was varied, the Pearson correlation coefficient between mean specificity and visual imageability was significant, $r(20) = .48$, $p < .05$. Similarly a significant correlation was shown between mean specificity and ease of predication in this word set, $r(20) = .47$, $p < .05$. It appears that when visual imageability is allowed to vary,

even small changes in differences in predicability can affect specificity of output in autobiographical memory.

In order to obtain further information on the relevant impact of these two variables on retrieval in autobiographical memory, a stepwise regression was performed on the data from Set B where significant correlations were obtained between memory specificity and both imageability and predicability. The two independent variables were imageability and predicability, and the dependent variable was mean specificity score for 20 cue words. The model stopped at Step 1 where visual imageability emerged as a significant predictor, $F(1, 18) = 5.39$, $p = .03$, $\beta = .48$, accounting for 23% of the variance in the specificity of autobiographical memory. The pattern of results from both correlational analysis on Set A and the regression analysis of Set B suggests that visual imageability is a more significant predictor of specificity in autobiographical memory than predicability.

GENERAL DISCUSSION

The aim of these experiments was to examine the role of imagery in the recollection of autobiographical memories, with particular emphasis on the level of specificity of material recalled. Previous studies had focused on quantitative aspects, examining the outcome of event retrieval. The question of how imagery affects the retrieval process itself had been relatively neglected. By focusing on a hierarchical model of memory, which contains different levels or nests of memories, and using a cue word methodology a number of discrete memory responses were obtained, which reflect the outputs from such nested hierarchies. By varying the imageability of the cue words we were able to manipulate ease of search through the hierarchy of autobiographical memory and see how such cues facilitate or impair the fluency of the retrieval process. High-imageable cues, particularly those cues that were high in visual imagery, facilitated access to more specific memories and speed retrieval of these events.

A semantic-knowledge-based account of imageability was also investigated to examine how such an account affected retrieval in autobiographical memory. Predicability has been proposed by Jones (1985, 1988) as an alternative knowledge-based account of how the effects of imagery are mediated. Given that the retrieval power of cue words would be influenced by variation in predicability, we examined predicability ratings for the cue words used in autobiographical memory tasks and compared these measures with other measures of imageability. Experiment 3 showed that both predicability ratings and the time taken to produce such predication statements correlated significantly with imageability ratings taken from Paivio et al.'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). As predicted, the greater the predicability of a cue word the more specific the memory and the faster the time taken to retrieve that memory.

Such a finding appeared to suggest that ease of predication is at least as good a predictor of specificity in autobiographical memory as imageability. These results raised the question, however, that if both measures were significantly correlated with specificity in autobiographical memory, then which one should be chosen as the most appropriate explanatory variable? The results of Experiment 4 suggest that visual imageability was the

more significant predictor of specificity in autobiographical memory when pitted against predicability. Given that typically specific autobiographical memories consist of a large proportion of visual event specific knowledge (Anderson & Conway, 1993), the finding that this advantage is mediated by the imageability of cue words confirms our initial hypotheses.

Of course the results of these experiments must be treated with caution as the words needed to be carefully selected to produce ratings in imageability that did not vary much in predicability and vice versa. It remains true that the naturally occurring high correlation between predicability and imageability indicates that they reflect closely related phenomena—that is, participants can produce predicates of words because they are easy to imagine and vice versa. For example, we can imagine a butterfly easily and our image includes a situational context: a butterfly sitting on a rose bush or resting against the kitchen window. To generate 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. It remains possible that, in everyday contexts, the generation of specific autobiographical memories involves both processes. Image generation activates semantic processing because imaging essentially entails accessing and searching knowledge structures in long term memory. Nevertheless the results of our experiments provide some preliminary evidence that when imageability is allowed to vary then both imageability and predicability appear to mediate specificity, but when imageability is restricted neither variable contributes to specificity. In other words, imageability emerges as the more powerful predictor, and without it, even relatively highly predicable cues are weakened significantly. Restricting predicability does not harm imageability's power to affect specificity, but restricting imageability does reduce predicability's effect on this aspect of autobiographical memory.

These data extend to the autobiographical memory domain the repeated finding that imagery enhances memory performance for verbal materials (Paivio, 1971, 1986; Richardson, 1980). The type of explanation provided for such effects typically postulates 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.

It is clear that imageability mediates more semantic associations, and that the dual effects of coding richness and parallelism are present in both traditional verbal learning tasks and 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 theoretical developments by Marschark and Surian (1989). It is also consistent with MEM (Johnson & Hirst, 1993), which does not make a separation between episodic and non-episodic memory "stores", but examines instead the way different material is encoded and later accessed. If, during encoding, a person does not note the context, the record of that context will not be available at recall. It is problems in the reflective subsystem—the monitoring of contexts–that are assumed to underlie memory problems in ageing and amnesia, as well as the confabulation of some brain-damaged groups and delusional patients. Recording the context is, however, not likely to be an all-

or-nothing affair. Rather, there will be differences in the amount of attention paid to the context, both between individuals (e.g. clinical vs. non-clinical groups) and within individuals over time (e.g. when a person is stressed or over-tired). The current results suggest that such individuals will have particular difficulty if they are unable to access imageable and predicable cues to help in their search for memories, and that imageability deficits will be particularly damaging.

The suggestion that visual imagery contributes a significant proportion of variance to memory specificity refocuses attention on the reason why visual processes are so important in retrieval. 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 earlier model of imagery (Kosslyn, 1980). Conway (1992) has also proposed that central executive processes are involved in the retrieval of autobiographical memories. Given the importance of imagery in the recollection of personal events, it is highly likely that the visuo-spatial sketch pad is involved in the dynamic construction of specific memories. If it is the case that greater effort is required to generate specific memories to 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 see parallel effects in people whose clinical status impairs their central executive capacity.

Depressed and suicidal patients have difficulty in recollecting specific autobiographical events, producing instead summary or "categoric" memories (e.g. "eating out in restaurants") rather than specific memories ("going to the Chinese restaurant last Friday night"). Such a deficit reduces the ability to solve current problems (Evans et al., 1992; Goddard et al., 1996) and increases hopelessness (Williams et al., 1996). We suggest that the retrieval style adopted by such clinical groups is comparable to that of participants when they are instructed to retrieve specific memories in response to low-imageable cues. The process of retrieval, which incorporates the cyclical retrieval strategy described by Williams and Hollan (1981) is a more difficult process for these patients who have naturally occurring restrictions in working memory capacity (Williams, Watts, MacLeod, & Mathews, 1997). They are both slow to generate mnemonic cues, and they produce more degraded cues with which to search memory. The result is that there are repeated successive cycles to find or construct a representation that satisfies the experimental constraints. After several iterations of the retrieval cycle, mnemonic interlock (Williams, 1996) occurs, in which it becomes increasingly difficult to move beyond the production of intermediate descriptions, and the search is eventually aborted before the patient has retrieved an event of the required specificity.

We have seen that, according to MEM (Johnson & Hirst, 1993), people experience different degrees of specificity, clarity, and confidence in the veridicality of the image while remembering, depending on activity in a "reactivation" subprocess. We suggest that the reactivation subprocess depends critically on the versatility of cues—that is, their fluency in forming images. Non-specificity of memory in depressed and PTSD (post-traumatic stress disorder) patients arises from (1) impairment in reflective processes at encoding, reducing the extent to which other events that are occurring at the same time are encoded; and (2) impairment in the reactivation subprocess at retrieval.

We suggest that the availability of highly imageable cues at retrieval affects the ability of the reactivation subprocess to find a match to a suitable encoding context necessary for the retrieval of an episode, whether that episode is a word in a verbal learning experiment or an event in an autobiographical memory task. Imageable cues are also highly interconnected semantically, and the versatility of access that this provides makes cue generation a relatively effortless process. Our results would suggest, however, that it is the visual imageability of cue words per se rather than predicability that mediates specificity effects in autobiographical memory. Images might represent the most efficient form of summary information that retrieval processes could use to search a memory trace. That is, they constitute the most economical way of representing information because they represent configurations of features that are easily accessible. In turn these configurations assist in further iterations in the retrieval process. This is consistent with Damasio's (1989) suggestion that when we experience an event, that experience is stored or represented in different regions of the brain as a multimodal memory, and that subsequent recall can be via any single modality that integrates all aspects of the experience. Highly imageable cues that are maximally informative can automatically activate such "convergence zones" to enhance retrieval. Furthermore, inasmuch as strategic recall from memory involves other executive subprocesses (such as structuring of materials and evaluating the outcome of the retrieval attempt), the use of highly imageable cues means that the working-memory system has the spare capacity to deploy any or all of these other subprocesses, should the recollection process demand them.

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APPENDIX 1A

Cue Words Used in the Autobiographical Memory Task, Experiment 1

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

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

APPENDIX 1B

Cue Words Used in the Autobiographical Memory Task, Experiment 2

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

APPENDIX 1C

Cues Used in Experiment 4

Set A		*Set B*	
bicycle	lightbulb	lawnmower	cough
butterfly	painting	broom	siren
cigarette	pen	cathedral	stairs
coin	radio	corkscrew	stubble
elephant	rose	fool	sunset
eye	spoon	field	skin
flower	star	yo-yo	typewriter
hair	telephone	heaven	thunder
house	water	horn	toothbrush
knife	window	thought	year