6

THEORETICAL PRINCIPLES OF CONTEXT-DEPENDENT MEMORY

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INTRODUCTION

When contextual cues affect remembering, memory is said to be context-dependent. Along with memory's dependence upon practice, similarity and temporal factors, contextual cueing represents one of the basic mechanisms used in theories of memory (e.g. Anderson and Bower 1973; Glenberg 1979; Hintzman 1988; Kintsch 1974; Raaijmakers and Shiffrin 1980; Thomson and Davies 1988). Context-dependent memory implies that when events are represented in memory, contextual information is stored along with memory targets; the context can therefore cue memories containing that contextual information.

There are many different operational definitions of context. 'Context' refers to that which surrounds a target, whether the surrounding is spatial, temporal or meaningful in nature. The present chapter will be limited to considerations of *incidental* context – that is, spatial and temporal contexts that are not obviously related to the targets on a memory test. The literature on meaningful contexts encompasses many research domains, including encoding specificity (e.g. Tulving and Thompson 1973), depth and spread of processing (e.g. Craik and Tulving 1975), and complex representational structures, such as scripts (e.g. Schank and Abelson 1977), schemata (e.g. Thorndyke 1977) or mental models (e.g. Glenberg *et al.* 1987). Although meaningful contexts may adhere to the same principles as those that apply to incidental contexts, they may also give rise to other meaning-driven phenomena that are beyond the scope of the present chapter.

This chapter will first briefly review empirical evidence related to incidental and context-dependent memory, including environmental

context- and state-dependent memory. These two research domains have found parallel patterns of results, implying that there are similar mechanisms at work. The empirical overview will be followed by a discussion of a set of principles for theories that deal with context-dependent memory.

SUMMARY OF EMPIRICAL FINDINGS

Environmental context

The incidental background surrounding a target refers to its environmental context. Although some have challenged the reliability of environmental context-dependent memory findings (e.g. Eich 1985; Fernandez and Glenberg 1985), the preponderance of empirical results shows that environmental context effects are found reliably (for reviews see Smith 1988; Vela and Smith 1992). A meta-analytic review of studies of environmental context-dependent memory in humans found that, across all published studies, context manipulations have reliably affected memory (Vela and Smith 1992). Not all effect sizes, however, are equal; variations can be found as a function of the memory paradigm used, the type of input processing given to the targets, and the type of test used to assess memory. Evidence related to these factors will now be briefly reviewed, and their theoretical significance will be discussed later.

Paradigms

The most popular memory paradigm used to assess incidental context-dependent memory has been reinstatement (e.g. Godden and Baddeley 1975; Smith 1979, 1985a). Reinstatement paradigms typically arrange for memory testing to occur either in the context in which target events were experienced, or in another context. Evidence of contextual cueing, then, is the finding that events are remembered better when the original context is reinstated, presumably due to the cues provided by the context. Effect sizes in reinstatement studies are reliably greater than zero, relatively small, on the average, and depend upon other factors to be discussed.

An early context reinstatement study used rats as subjects (Carr 1917). Carr found that if a rat learned to run a maze that was oriented in a particular way towards the overhead room lights, performance was better if the lighting arrangement was reinstated, rather than

altered. Animal learning and memory studies of context effects now constitute a sizeable literature composed of highly reliable findings (Balsam and Tomie 1985).

Studies examining incidental contextual reinstatement effects on humans were reported by S. Smith and Guthrie (1927), in which verbal targets were used, and context was operationally defined as indoors v. outdoors, and presence v. absence of the odour of oil of wintergreen. As with the animal studies, people recalled more when the incidental environment was reinstated. Since the time of that report, many other incidental contextual manipulations have resulted in reinstatement effects, including under water (with scuba gear) v. on dry land (Godden and Baddeley 1975), with Beethoven v. jazz music playing (Smith 1985a), in a sensory deprivation flotation tank v. a lounge (Smith and Sinha 1985) and, most commonly, in one laboratory room v. another (e.g. Smith 1979; Smith *et al.* 1978; Smith *et al.* 1990).

Physical reinstatement of incidental environmental contexts is not always necessary to achieve contextual cueing effects. Subjects tested in an altered context who are instructed to imagine the learning context recall as much as those who are physically returned to the learning environment (Smith 1979, 1984). Imagined context reinstatement instructions have also proven to be effective recall aids in situations involving eyewitness memory (e.g. Malpass and Devine 1981). Such instructions constitute an important component of 'guided memory' methods, which have been shown to improve eyewitness memory in a number of studies (e.g. Fisher *et al.* 1984; Geiselman 1988). Theoretical implications of the findings that subjects can imaginally generate their own context cues will be considered later in this chapter.

The interference reduction paradigm (e.g. Bilodeau and Schlosberg 1951; Greenspoon and Ranyard 1957) uses a target list and an interfering list that are learned either in the same environments or in different environments (Table 6.1). When interference effects are reduced because the lists are learned in different environments, that is taken as evidence of context-dependent memory. If contextual cues are associated with only the target list rather than with both the target and interfering lists, then the contextual information used in recall should cue fewer interfering memories.

Incidental context effects have been more robust with interference reduction than with physical reinstatement paradigms (Smith 1988; Vela and Smith 1992). The most cogent explanation of this pattern

Table 6.1 Retroactive interference reduction paradigm

	Control group	*Interference reduction*
1. Original list learning	Context A	Context A
	.	.
	.	.
	.	.
2. Interpolated list learning	Context A	Context B
	.	.
	.	.
	.	.
3. Recall test for first list	Context A	Context A

relates to the idea expressed earlier that subjects can generate their own imagined context clues from memory. Bjork and Richardson-Klavehn (1989) suggested that subjects in the interference reduction group have no reason to mentally reinstate the interpolated list context, as it should not cue memory for the initial list, and it would be counterproductive because it would revive interfering memories. Those subjects in the control group cannot use context cues to differentiate the two learned lists, and therefore suffer from interference. In contrast, subjects in physical reinstatement studies can imaginally generate their own context cues if they are tested in an altered context. To the extent that subjects spontaneously use imagined context to cue memory in reinstatement paradigms, the observed differences between physically challenged v. reinstated contexts will be reduced.

Although relatively few studies using the multiple input context paradigm have been reported, it has proven a reliable method for observing context-dependent memory (Smith 1982, 1984, 1985b; Smith and Rothkopf 1984). In this paradigm a target set is studied repeatedly and tested with a free recall test. The study sessions are conducted either all within a single context or each in a different context. Recall is typically tested in a new unfamiliar context in all conditions. The usual result is that material is recalled better if the input contexts are varied rather than kept constant. This effect differs from the more common reinstatement findings because it examines context-dependence (and independence) as a function of input conditions, independent of retrieval conditions.

Type of test

The type of memory test given to the subject is influential in determining whether or not incidental context-dependent memory is found (Smith 1988; Smith *et al.* 1978; Vela and Smith 1992). The rule that appears to apply most generally among context-dependent memory studies will be referred to as the 'outshining' principle (Smith 1986, 1988; Vela and Smith 1992), which states that tests that provide non-contextual cues, or that encourage subjects to generate such cues from memory, are the *least* likely to find context-dependence. The outshining principle will be briefly discussed in relation to test type and type of input processing, in addition to theoretical implications of the principle.

Because memory tests cue subjects, they must provide the subject with memory cues of one type or another. Tests differ in terms of the cues they provide; cues can vary in terms of their number, strength of association with targets, specificity (number of targets associated with a cue), and a variety of other dimensions. Cues on a free recall test, for example, are few, weakly associated with targets and general (non-specific). Free recall instructions typically provide little, instructing subjects simply to recall items from a list in any order. In contrast, recognition tests provide many specific cues that are strongly associated with memory targets; the targets, themselves, are supplied on the test. Consistent with the outshining principle, contextual reinstatement effects are likely to occur on a free recall test, in which few non-contextual cues are provided (e.g. Godden and Baddeley 1975; Smith 1979, 1985a; Smith *et al.* 1978), but they are not likely to occur on a recognition test, when many strong cues are given (e.g. Godden and Baddeley 1980; Jacoby 1983; Smith *et al.* 1978).

The outshining principle also indicates that tests that encourage subjects to use non-contextual cues, even those generated imaginally from the subjects' own memories, are less likely to find effects of incidental contextual manipulations than tests that do not encourage the use of non-contextual cues. Traditional tests of memory, such as recall and recognition, are known as *direct* memory tests because they explicitly direct the subject to remember the target events in question (Richardson-Klavehn and Bjork 1988). In the course of intentionally trying to remember target events the subject may feel encouraged to use any cues that are provided or that can be generated from memory, including non-contextual cues. Therefore, direct memory tests may

encourage the use of non-contextual cues, which would diminish findings of context-dependent memory.

Indirect memory tests, on the other hand, are tasks that do not direct the subject to the memories in question, but that are sensitive to memories nonetheless (Richardson-Klavehn and Bjork 1988). The most commonly reported indirect memory test is the word completion task, in which the subject sees a fragment or a stem of a word, and must complete the word by providing the remaining letters (e.g. Tulving *et al.* 1982). Results typically show that completion of word fragments is better for words recently presented than for words not recently studied (e.g. Tulving *et al.* 1982). Another indirect memory test is spelling of spoken homophones (e.g. BARE/BEAR, GROWN/GROAN). If subjects study a set of homophones on a list, memory is indicated when subjects spell homophones consistent with the studied set, rather than giving alternate spellings (e.g. Jacoby and Witherspoon 1981). A third indirect test is the general knowledge test. On this test subjects may be biased to give previously studied words as answers when they guess at general knowledge questions. Indirect memory tests focus subjects' attention on tasks other than memory for a studied list; thus, observed remembering is unintentional.

Because they do not encourage the use of cues for remembering event memories, indirect measures should be ideal for observing context-dependence. Although relatively few such studies have been reported, those reported have shown robust effects of context-dependence. Smith *et al.* (1990) found effects of context manipulations using a homophone spelling test, and Vela (1991) found effects on both fragment completion and general knowledge tests. These results are consistent with the outshining principle.

Associative processing at input

Vela and Smith's (1992) meta-analysis also found that incidental context effects are modulated by the type of input processing used when targets are learned. Specifically, they noted that in the reported literature context effects have been most likely to occur when learning instructions prevented associative processing among the targets, and least likely when associative input processing was encouraged. For example, Smith (1986) presented target words incidentally, on trials of a short-term memory (STM) task, a task that would discourage associative input processing. In that study context-dependence was observed even though a recognition memory test was used. In

contrast, Fernandez and Glenberg (1985) had subjects construct sentences with target words in several experiments, thus requiring associative input processing, and failed to observe context-dependence even using a free recall test.

Although subjects can use many different sources of cues to aid memory, associative cues are especially helpful, particularly when words are used as memory targets. Because cues can be generated from memory even when they are not explicitly provided by the memory test, associative cues can be used as long as they have been established at input. Therefore, associative processing at input encourages the use of non-contextual cues at test, thus minimizing the effects of incidental context cues in accordance with the outshining principle.

Intrinsic context

Geiselman and Bjork (1980) distinguished between contextual information which is extrinsic to the memory targets that are under scrutiny, and that which is intrinsic to the targets. The incidental contextual cues referred to above represent extrinsic context cues because they are not actually part of the verbal memory targets used in those studies. An intrinsic context cue, in contrast, is an incidental characteristic of the target itself, such as the voice in which a target is spoken, or the type font or colour of a printed stimulus. For example, Dulsky (1935) manipulated the colour backgrounds of paired associates that were presented and tested on coloured cards, and found a context-dependent effect: memory was best when the colour backgrounds at input and test matched.

The voice contexts of word targets were manipulated along with rehearsal type (elaborative v. rote rehearsal) and rehearsal duration by Geiselman and Bjork (1980), who used a recognition test to assess memory. When subjects studied the words by using elaborative rehearsal, no effect of reinstating v. altering the speaker's voice at test was found. With rote rehearsal, however, voice context-dependence was observed, with the effect getting stronger for longer rehearsal durations. Geiselman and Bjork (1980) and Baddeley (1982) suggested that intrinsic context cues may affect recognition memory, in contrast to extrinsic context cues, which often do not appear to affect recognition (e.g. Godden and Baddeley 1980; Smith *et al.* 1978). Since the Geiselman and Bjork (1980) study, however, findings of recognition affected by extrinsic context have been reported (e.g.

Canas and Nelson 1986; Smith 1986; Smith and Vela, in press).

Another study of intrinsic context effects (Wright and Shea 1991) manipulated features of computer displays, examining the context-dependence of typing brief practised sequences. Subjects practised typing 3- and 4-key sequences which were cued by 3 or 4 corresponding digits displayed on a computer screen. Each of 3 sequences practised was always presented in a characteristic position on the screen (top, middle or bottom), in a particular colour (blue, red or yellow), with a specific shape outline around the digits on the screen, and with a particular accompanying tone. No mention was made of these incidental stimuli to the subjects. Wright and Shea found that for the more difficult 4-key sequences subjects were more prone to errors when context cues were suddenly switched or removed than when they were reinstated.

In general, it can be concluded that intrinsic context cues function in much the same way as extrinsic cues. Whether their effects are more reliable than those of extrinsic cues may depend upon other factors, such as how overloaded the cues are, whether they are overshadowed at input, or outshone at test. These issues will be discussed in a later section.

State-dependent memory

When memory depends upon manipulations of internal states rather than external stimuli, it is said to be state-dependent. Internal states refer to drug-induced or pharmacological states and mood states. As with incidental environmental context effects, state-dependent memory studies show that reinstatement of learning conditions optimizes recall. Most state-dependent studies have used a reinstatement paradigm (see Eich 1980 and 1989 for reviews).

State-dependent memory results are often 'asymmetric', a term used to indicate a particular configuration of results when an experimental design uses two drug states at input and at test, referred to as 'drug' and 'placebo'. The two reinstated conditions are those with input and test both in the drug condition, or both in the placebo condition. The altered state conditions are those having input in a placebo state and test in a drug state, and those with input in drug and test in placebo states.

If the drug had no main effect on either learning or recall, then an input state by test state interaction would be symmetric; having input and test both in the drug state would be equally as beneficial to

memory as having input and test both in the placebo condition. Both of the altered state conditions would also perform equally well, both at a lower level than the two reinstated conditions. An asymmetric result, on the other hand, would be a main effect of drug and a state-dependent interaction. For example, if alcohol impairs recall but shows a state-dependent effect, then the pattern of results is asymmetric (e.g. Eich 1989). The asymmetric result is particularly fascinating because a drug that typically impairs long-term memory (i.e. alcohol) can actually enhance memory if the target material was learned while in that drug state (e.g. Stillman *et al.* 1974).

Although state-dependent memory effects have at times been criticized as unreliable, Eich and others (Eich 1980, 1989; Eich and Metcalfe 1989) have shown that state-dependent effects depend upon the cues that are present at test, and that the effects require a reliable manipulation of internal states. When these factors are taken into account, reliable state-dependent effects are found.

When memory tests that provide good memory cues are used to assess state-dependent memory, the effects are small or non-existent, as is the case with environmental contextual cues. For example, recall of a categorized word list tested using marijuana-induced states was found to be state-dependent if a free recall test was used, but not if recall was cued with category cues (Eich *et al.* 1975). Furthermore, Eich (1980) showed that cued recall and recognition tests, which provide specific memory cues, were less likely than free recall tests to show state-dependent effects.

A second necessity that is critical for observing state-dependent memory effects is a reliable manipulation of internal states. For example, Eich (1980) concluded that drug state-dependent effects required effective doses of drugs, noting that studies whose drug treatments did not cause main effects on acquisition or retention usually did not observe state-dependence. Observations of mood-dependent memory may also depend upon the reliability of mood manipulations. Mood induction techniques that use hypnosis or thinking of affectively valenced memories may place too much reliance on the subject's willingness and ability to cooperate. One method that looks promising for reliably inducing mood states combines a continuous self-report procedure with listening to affectively valenced music (Eich and Metcalfe 1989). Studying and testing of targets are undertaken only after the subject's self-reports indicate a sufficient mood change.

Mood-dependent memory must be distinguished from mood-

congruent memory (e.g. Blaney 1987). Mood congruence is the finding that emotionally laden stimuli are learned and remembered best when their affective valence matches the subject's mood. For example, in a depressed mood, a subject might learn and remember negatively valenced words, such as 'funeral' or 'sorrow', better than positively valenced words, such as 'funny' or 'carnival'. Although mood congruent effects resemble mood-dependent memory effects, they are not the same. Mood-dependence is a principle that relates study and test moods to each other, whereas mood congruence describes a relation between subjective moods and target stimuli.

THEORETICAL PRINCIPLES

A number of basic principles can be induced from the empirical studies reviewed above. Although these principles are intended to explain contextual dependence, they do not necessarily imply specific theoretical mechanisms. Principles such as cue overload, outshining or decontextualization can be implemented with different theoretical mechanisms in different theories. Any memory theory, however, that involves context-dependent memory should incorporate these basic principles.

The principles to be considered here will include cue-dependence, overshadowing, contextual fluctuation, cue overload, memory probe, outshining and decontextualization.

Cue-dependent memory

The principle of cue-dependent memory is simply that performance on memory tasks is influenced by associated memory cues. If contextual information is associated with target material, then contextual cues should stimulate memory for associated material.

There are many theoretical mechanisms that can explain context-dependent memory, and a few will be described here. These include activation of a set of information in memory, direct context-to-item associations, mediation by internal states, and activation of cognitive operations.

Activation of a search set

Shiffrin (1970) described retrieval as a probabilistic iterative process involving sampling-with-replacement from a delimited set of

information in memory. The delimited set was referred to as a 'search set', or the set of information in memory that was to be deliberately searched. By keeping memory searches within this set, one's retrieval efforts could be more efficient than if all of memory were searched.

Smith *et al.* (1978) hypothesized that incidental environmental contexts may cue memory by helping to delimit such a search set. In terms of Shiffrin's (1970) memory search model, this might mean that only memories with contextual associations are included in the search set. This search set hypothesis is consistent with findings in both environmental context- and state-dependent studies that recall is more likely than recognition to be affected by context manipulations (e.g. Eich 1980; Godden and Baddeley 1975, 1980; Smith *et al.* 1978). Although retrieval is of fundamental importance in free recall, in which the subject must search memory to find targets, it is not as important a process in recognition memory tasks, in which targets are supplied by the experimental task. Thus, contextual delimitation of a search set would be less likely to affect recognition memory.

Context-to-item associations

The exact nature of context-to-item associations depends upon whether one conceives of contexts and items as unitary or multi-componential. A unitary context or components of a context can be associated with clusters of targets, individual targets or components of targets. There are many possible conceptions of contextual associations, but all involve direct associations of contextual information with target information. An example is SAM (e.g. Raaijmakers and Shiffrin 1980), in which each word in long-term store is associated to some varying degree with a representation of the context.

Theories that employ direct context-to-item associations would all appear to predict that item familiarity should be increased when input and text contexts match. For example, Kintsch (1974) described a matching process in which a cue, containing perceptual, contextual and semantic information, is matched with episodic memory codes. The greater the overlap of contextual elements in the cue and memory codes, the likelier it is that the match will be successful. This matching process, for example, is the basis of Kintsch's description of recognition memory judgements.

The evidence that incidental context affects performance on familiarity-based memory tasks is inconclusive. Recognition memory tasks have been found to be less sensitive than recall to incidental

context manipulations. Several studies using incidental contexts have failed to show context-dependent recognition, even under the same conditions that produce context-dependent recall (e.g. Godden and Baddeley 1975, 1980; Smith *et al.* 1978). On the other hand, other studies *have* found incidental context-dependent recognition effects (e.g. Canas and Nelson 1986; Leight and Ellis 1981; Smith 1986; Smith and Vela, in press). Furthermore, indirect memory measures that furnish target items for subjects (thus limiting the need for retrieval) have been found to be sensitive to context-manipulations (e.g. Smith *et al.* 1990; Vela 1991). These results support the notion of direct context-to-item associations.

Mediation by internal states

Results of state-dependent memory studies show that memory is modulated by relations between internal states at input and at test. Eich (1989) has hypothesized that the mechanisms responsible for internal state-dependent memory are also the ones involved in external context-dependent memory. If configurations of external stimuli help cue internal states, then reinstatement of external contextual stimuli could reinstate the internal state that was present at input. Thus, observations of external context-dependent memory could be mediated by internal states.

Logically, one must have an internal representation of an input context if reinstatement of that context is to cue associated memories. An external context can therefore affect memory only by mediation of an internal representation of the context. Whether a representation of a context is a mood or some other form of internal state must depend upon one's definition of an internal state. The state-mediation hypothesis, however, implies that an internal *response* to an environmental context, not a representation of it, leads to reinstatement of memories. That internal response might be labelled an affect, a mood or some other type of state.

One implication of the state-mediation hypothesis is that there are stimuli that reliably induce the same mood. In support of this notion, Eich and Metcalfe (1989) have found that certain musical selections consistently induce the same mood across subjects. Another implication of the state-mediation hypothesis is that environmental contextual changes that result in context-dependent memory should also induce consistent internal states. In separate studies, music backgrounds have been used to observe context-dependent memory (Balch *et al.*

1992; Smith 1985a) and mood states (Eich and Metcalfe 1989). If a single study manipulated external contexts and measured internal states, it would be expected that internal states would be better predictors of memory performance than environmental contexts. At this time, such tests have not been conducted.

Activation of cognitive operations

Stillman *et al.* (1974) proposed a fascinating hypothesis in relation to state-dependent memory. Using the analogy of memory as a set of storage files, they proposed that, rather than conceiving of different internal states as separate file drawers, one could think of each state as using its own distinct filing system. In cognitive terms, different cognitive operations would be used for different classifying systems. At input a particular set of cognitive operations would be cued by the prevailing state, and those operations would be used to classify the studied material. At test, if the same operations were cued by a reinstatement of the input state, then the same classifying system could be effectively used to retrieve information. Altering the state at test would cue different cognitive operations, resulting in the use of an inappropriate classifying system for searching memory.

The notion of context as an activated set of cognitive operations was also discussed by Bower (1972), who elaborated ideas proposed by Estes (1955). Those ideas will be discussed briefly in a later section on contextual fluctuation.

Overshadowing

Not all information in the stimulus environment is necessarily encoded and stored in memory. A feature may not be stored when other more salient features are present in the environment because of a limited attentional capacity to encode and store features of stimuli.

Overshadowing and blocking are well-known phenomena in the domain of animal learning and cognition, both of which essentially show that a stimulus that can be learned when presented in isolation might not be learned when another stimulus is present. For example, a thirsty animal can be trained to suppress licking when a tone (Cue 1) is used as the conditioned stimulus, or trained with a light (Cue 2), but when both tone and light are used as a composite conditioned stimulus, the subject shows learning only for the tone (e.g. Matzel *et al.* 1985). This situation is depicted in Table 6.2, and is referred to as 'overshadowing'.

Table 6.2 Overshadowing

	Learning	*Test cue*	*Mean log latency (sec)*
Cue 2 Learning	Pair Cue 2 with target	Cue 2	2.0
Cue 1 and 2 (Composite) learning	Pair Cue 1 plus Cue 2 with target	Cue 1	2.3
		Cue 2	1.2 (overshadowing)

Note: Cue 1 is a strong cue, and Cue 2 is a weak cue. Sample data are from Matzel *et al.* (1985). Higher scores indicate better memory performance. Overshadowing is found: Cue 2 is ineffective if learned simultaneously with Cue 1 as part of a compound stimulus.

Overshadowing has usually been attributed to a failure in learning the weaker cue (Cue 2, the light). Although various mechanisms have been proposed for this storage failure, one that is relevant to the present topic is that the subject's limited attentional capacity becomes taken up by the more salient cue, preventing attention, and therefore learning, of the weaker cue (e.g. Mackintosh 1975).

Geiselman and Bjork (1980) gave essentially the same explanation for their findings that recognition memory was context-dependent following primary rehearsal, but not after secondary rehearsal at input. They proposed that, with secondary rehearsal, inter-item associations occupied the subject's attentional capacity, reducing the amount of attention that could be used to store contextual information. Primary rehearsal occupies far less attentional capacity, allowing more resources to be devoted to learning contextual cues. In terms of overshadowing, context-dependent memory was not observed following associative rehearsal because learning of the weaker context cue was diminished owing to attentional resource limitations. This learning-based explanation of why context effects are sometimes not observed contrasts with the outshining hypothesis, which focuses more on retrieval explanations. Outshining will be considered in a later section of this chapter.

Contextual fluctuation

William James' (1890) idea of the 'stream of consciousness' indicated that the thoughts with which one apprehends the world fluctuate over time, changing, while remaining related to what has gone before. Because of this fluctuation of consciousness, James also pointed out

the idea that a thought cannot be re-experienced in exactly the same way twice, because the consciousness in which it appears has flowed and changed from the previous occasion.

Contextual fluctuation theory (e.g. Bower 1972; Estes 1955) can be considered an approach to the study of the stream of consciousness. The theory uses a statistical analysis of fluctuations in thinking, applying this analysis to the issue of how a stimulus is apprehended on different occasions. Estes (1955) noted that, in a given stimulus environment, only a subset of the stimulus elements are conditioned on any learning trial. For example, if the word 'MOUSE' were given as a to-be-learned target in a memory experiment, it could be encoded in several different ways, such as 'a small animal', a word that rhymes with 'house', a computer peripheral device or a noun beginning with the letter 'm'. Bower (1972) postulated that each target is encoded by an active encoding operator, and that the set of operators active at any given moment is smaller than the entire set of possible operators.

Bower (1972) defined context as the sum of external and inter-operative stimuli that accompany a target stimulus, placing particular emphasis on 'mental set', a product of the stream of consciousness. Furthermore, he stated that the active set of encoding operators was influenced by the prevailing context (this notion of context-dependence was previously referred to as 'activated cognitive operations' [Stillman *et al.* 1974]). Bower formulated the 'contextual drift' hypothesis, which states that, in lieu of systematic changes in context, there will be a gradual fluctuation of external events as well as internal mental events that increases contextual changes over time. Therefore, the probability that the same encoding operators are active on two occasions decreases with greater time owing to greater contextual drift (Figure 6.1).

The contextual drift hypothesis represents an alternative to theories based on the passage of time. Because time passage correlates with contextual drift, according to this view, context-dependent phenomena may seem to be time-dependent. Systematic manipulation of contextual cues, however, supersedes temporal changes because the critical determinant of the active set of cognitive operators is context.

Mensink and Raaijmakers (1988, 1989) have formally incorporated a temporally determined mechanism for contextual fluctuation in the SAM memory model proposed by Raaijmakers and Shiffrin (1980). Following from Estes (1955) and Bower (1972), they have proposed that fluctuation between the active and inactive sets of

contextual elements is a stochastic time-dependent process. The model simulates and predicts several phenomena related to interference, such as spontaneous recovery and proactive interference.

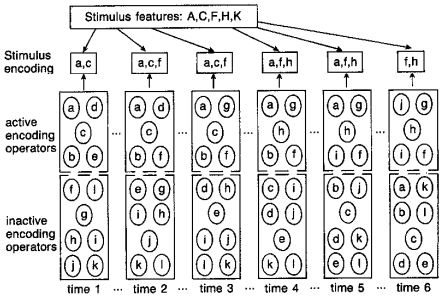

Figure 6.1 Fluctuation between the sets of active and inactive encoding operators yields cognitive contexts that differ more as more time passes.

Glenberg's (1979) component-levels theory took an important step beyond earlier formulations, of contextual fluctuation, because it noted that environmental fluctuation is not random in most memory experimental contexts; faster changing cues are likely to be more specific than slower changing cues. The fastest changing cues in a typical list-learning memory experiment are those that represent and distinguish the separate items studied on a target list. These are called *descriptive* components because they describe characteristics of a target item, such as its spelling, phonology and meaning. The next fastest changing components are called *structural* because they represent an item's associative or categorical structure. Several items, each with different descriptive components, may all belong to the same associative structure. The slowest changing components are *contextual*, because all of the items are studied within the same general context. Contextual components are the most general because essentially all of

the target traces contain the same contextual information. Descriptive components are the most specific because no two items contain the same descriptive information. It will presently be shown how a cue's specificity determines the cue's strength; for the moment, however, it is most relevant to note that contextual, structural and descriptive information do not typically fluctuate in a completely random fashion, as characterized by earlier accounts of contextual 'drift'.

Cue overload

The more targets that are associated with a cue (i.e. the more overloaded it is), the less likely it is that a specified target will be generated in recall, given the cue in question. This is the cue overload principle (Watkins and Watkins 1970). Although cue overload was originally used to explain the build-up of proactive interference on short-term memory tests, the principle has considerable value for understanding a variety of cognitive phenomena, among them context-dependent memory.

Glenberg (1979) used the principle of cue overload to explain the differential effectiveness of descriptive, structural and context cues. Descriptive cues are the most specific because each is associated with a distinct target. Their cue strengths are greater than those of structural cues, which have more associated targets, and are thus more overloaded. Context cues are the most overloaded, being associated with all targets, and are therefore the weakest cues.

Poorer recall has been found for list learning that occurs all in a single context than when parts are learned in different contexts (Smith 1982, 1984; Smith and Rothkopf 1984). This supports the notion of cue overload in contextual cueing. The context cue in the single context condition is more overloaded than the cues in the multiple input context condition, and is therefore a weaker cue.

Memory probe

A memory probe is a theoretical mechanism that assembles information for searching memory. According to the principle of cue-dependence, information included in the memory probe elicits retrieval of memory traces that contain that information. Many theories use the device of a memory probe, including SAM (e.g. Raaijmakers and Shiffrin 1980), CHARM (J.M. Eich 1982) and MINERVA 2 (Hintzman 1986). For example, SAM is endowed with

a short-term memory store in which cues are assembled and used to probe long-term store. Governed by a recovery rule, the probe samples information in memory that is then accessed and evaluated.

Similarly, MINERVA 2 uses a probe that activates information in long-term (secondary) memory. The information that is activated is referred to as the 'echo', which is placed in short-term (primary) memory. This echo has an intensity, which is used as an indication of familiarity, and a content, which refers to the set of information coded in the echo. The term 'echo' will be borrowed for the remainder of this chapter to refer not only to Hintzman's MINERVA 2 model, but more generically, to any model that uses the idea of a set of information that results from the process of probing long-term memory.

What information is included in a probe when memory is searched? There must be a system for determining the contents of the memory probe. For most models the information included in a probe consists primarily of representations of the cues provided by the memory test, as well as cues resulting from a previous probe of memory (e.g. Hintzman 1986; Metcalfe 1982). If no cues are formally provided, the SAM model begins probing memory with only a context cue until initial retrievals provide more cues to be included in subsequent probes.

Unfortunately, such probe composition systems do not adequately characterize the multiplicity of methods that subjects may use to search memory; one may recall a list from beginning to end, in alphabetical order, in terms of a story or link mnemonic, or in a variety of other ways. Critical to the issue of context-dependence is the finding that subjects can generate their own context cues from memory, although they may not do so spontaneously (Smith 1979). A subject is therefore able to voluntarily include a context cue that is not physically present in a memory probe.

It is proposed that both an expert system that generates cues for a given task and a default system are needed to create a policy for determining the contents of a memory probe. By default, a memory probe will include representations of provided cues, recently revived memories and ambient contextual information. Therefore, on an implicit memory test the incidental test context can be expected to affect memory because the subject is not motivated to include non-ambient contextual information in the memory probe (Smith *et al.* 1990). On an explicit test, however, if testing occurs in an altered context, an expert system can include relevant non-ambient contextual

information in a memory probe owing to instructions or prior experience with such self-generated cues.

Outshining: Hidden context effects

The idea of outshining uses a psychophysical metaphor; a dim light, such as the light one sees from a star, is more difficult to detect when there is more background light, as compared with the same light when the surroundings are darker (Smith 1988). Although the outshining principle can be formulated as a mechanism that obeys psychophysical laws, it can be supported by several other mechanisms as well.

To determine whether or not a particular cue, such as a context cue, has been learned, one should test memory with the cue present v. absent. This assumes that subjects do not generate the cue from memory, as previously discussed. If memory is enhanced by providing the cue, this result is taken as evidence that the cue was learned. Would an absence of an effect indicate that a cue was not learned? Such could be the case, but there are alternative possibilities as well, even if the cue was successfully stored in memory. For example, there may be questions about the sensitivities of various memory tests for detecting the cues in question, and statistical power concerns. It may also be that learning was not detected because the subject used other cues to guide memory. Such a case, in which the learning of a cue is not detected because subjects use alternate cues, is referred to as outshining. Outshining (Table 6.3) differs from overshadowing (Table 6.2) in that outshining occurs not because of a learning failure, but rather because test cues prevent detection of the learned cue. Several theoretical mechanisms that could account for outshining will now be briefly described.

Subadditive cueing

When two (or more) cues are provided by the test or the experimenter, their combined effectiveness (relative to testing with neither cue provided) may be equal to the sum of their independent cue strengths (additivity), greater than the added strengths (configural or superadditivity), or less than the added strengths (subadditivity). Of interest here is the subadditive case, in which the combined effectiveness of two cues is less than the sum of the effectiveness of the two cues measured independently.

Table 6.3 Outshining

	Learning	*Test cues*	*d'*	
Same context; no strong cue	Pair Cue 1 plus Cue 2 with target	Cue 2	1.5	Context dependence; no outshining from strong cue at test
Different context; no strong cue	Pair Cue 1 plus Cue 2 with target	No cue	1.1	
Same context with strong cue	Pair Cue 1 plus Cue 2 with target	Cue 1 and Cue 2	1.8	No context dependence; outshining from strong cue at test
Different context with strong cue	Pair Cue 1 plus Cue 2 with target	Cue 1 alone	1.8	

Note: Cue 1 is a strong cue, and Cue 2 is a weak context clue. Sample data are from Smith and Vela (1986). Higher scores indicate better memory performance.

Subadditivity has been used to infer that cues contain redundant information; a second cue only benefits memory to the extent that it adds new information to a memory probe not provided by the first cue. For example, Tulving and Watkins (1975) proposed that memory traces consist of many components, each of which can be cued by related information in a memory probe. The power of each cue for evoking a memory refers to the cue's valence. If a combination of two cues produced as much memory cueing as the sum of the cue valences, the two stimuli would be considered to cue non-redundant components of the target trace. On the other hand, if components of the trace are cued by both stimuli, the cues would be said to contain redundant information.

For example, as illustrated in Figure 6.2, a memory trace representing the studied word 'CHAIR' might contain both phonological and semantic components. A memory probe containing the retrieval cue 'BEAR' might overlap with only the phonological component, whereas the cue 'STOOL' might coincide with only the semantic component. As such, the two cues would be said to be non-redundant, and memory cueing would be an additive function of the two cue valences. On the other hand, the cue 'BEAR' and the cue 'FARE' both coincide with a phonological component of the target trace; thus,

a combination of the two cues might produce a cueing effect equal to less than the sum of the two cue valences.

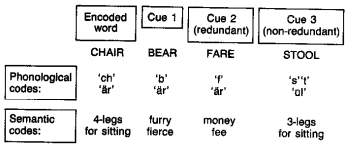

Figure 6.2 Cues 1 and 2 redundantly cue the target because they share a phonological component that overlaps with the encoded features of the target.

A memory cueing technique called the reduction method (Tulving and Watkins 1975) consists of probing a memory trace with two different cues in succession to determine the overlap among cues with respect to a given memory trace. This is based on the idea that each cue may be associated with a set of the components of a target memory trace. If two cues are associated with completely redundant components of the target memory trace, then a composite of the two cues will provide no greater access to the target trace than would either cue individually. Only if the cues are completely non-redundant should a composite of the two give additive cueing effects.

Signal detection approach

A signal detection approach to outshining might use a monitoring system that detects the information activated when a memory probe addresses long-term memory (i.e. the echo). Adding relevant cues to the memory probe should increase the echo intensity by increasing the similarity between the probe and the material stored in memory. A system that monitors the echo's intensity should therefore be sensitive to the effects of adding memory cues to a test situation.

Figure 6.3 shows strength distributions for studied and non-studied items. The top distribution shows strengths for items cued by a weak cue (e.g. a context cue), and the middle distribution corresponds to memory strengths elicited by a strong cue (e.g. an associative cue).

Assuming that adding a cue to the probe shifts the stronger distribution a fixed amount (related to the cue's *strength*), the amount of the distribution that *surpasses* the memory criterion as a result of the cue is indicated by the shaded area. The shaded areas will be referred to as the *cueing effects* of the cues. Of particular relevance is the effect of the weak context cue (darker shading) when the strong cue is absent (top) v. present (bottom) in the probe. The same cue can be seen to have a much smaller effect when the strong cue is present as compared to the effect when the strong cue is missing. Thus, in this signal detection analysis, outshining is represented by the smaller effect that a weak context cue has when a strong cue is present.

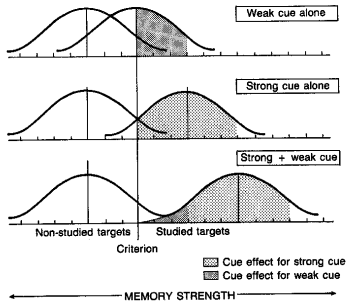

Figure 6.3 Adding a cue shifts the distribution of studied targets past the criterion.

It should be noted, however, that the same signal detection analysis predicts outshining (subadditivity) only when the strong cue exceeds a particular strength. If the cues are weak enough, their combined effects can be superadditive, just as can be demonstrated with psychophysical power functions. Of relevance to the present chapter, however, is that when the strong cue is strong enough, a signal detection

analysis can explain findings in which contextual cueing effects are not detected owing to the presence of strong cues.

Submergence

Another hypothetical mechanism responsible for outshining will be referred to as 'submergence'. Submergence refers to cases in which a combination of cues in a probe alters or masks features of the cues that would otherwise overlap with information encoded in the target memory trace. This is suggested as the opposite of emergent or configural properties that might produce superadditive cueing effects. Submergence might occur when cues are processed differently at test than at input, such that the composite cue has properties different from those processed at input. The idea of submergence is highly speculative, and has not been the subject of empirical investigations.

Limited probe capacity

Outshining might also occur if the memory probe has a limited capacity. This idea is similar to the attentional theory of overshadowing (Macintosh 1975), except that the limitation is not at the time of learning but at test. The probe's limited capacity may limit encoding (or assembly) of a memory probe. When both cues are provided, one might displace the other from memory probe, making the cues subadditive.

Decontextualization

When evoking a memory no longer depends upon contextual cues, the memory can be said to be decontextualized. The first time a piece of information is experienced, such as the name of a new acquaintance, the context may be a relatively important component of the name's representation in memory. Alternately, a piece of information that is experienced in many contexts, such as a close friend's name, is more likely to be decontextualized. The difference between context-dependent knowledge is essentially the difference between episodic and semantic memories (Tulving 1972).

Hintzman's MINERVA 2 model of memory (e.g. 1986) provides a mechanism for decontextualization of items that are experienced multiple times. Each different experience of an item is represented as a separate memory trace. Although the contexts in which an item is

experienced may vary, there must be some information in each trace that is consistent; otherwise the different memory traces would not be considered to represent the same item. When MINERVA 2 searches memory using a probe in which a target item is represented, the echo that is returned contains a summation of all memory traces in which the item is encoded. The content of that echo will reveal primarily the features common to all or most of the traces. Contextual information, however, may vary greatly among the traces summed in the echo. Thus, no one particular context is clearly specified in the echo, whereas one prototype represented by the common features of the target item is clearly delineated. Because memory of the prototype is not dependent upon any one context cue, the memory can be considered to be decontextualized.

Of course, if an item is consistently associated with a particular context, then even a large number of memory traces would be context-dependent, because that context would be as consistently represented in an echo as the other consistent features of an item. In effect, the context would appear to be a defining feature of the item, and the item would remain context-dependent. This pattern is supported by empirical evidence that shows that memory of target items repeated in the same context are more context-dependent than items repeated in different contexts (Glenberg 1979; Smith *et al.* 1978). Therefore, both theory and empirical evidence suggest that practice in varied contexts enhances decontextualization.

SUMMARY

Incidental background contexts, such as environmental settings, moods and drug states, have been found to reliably affect memory. Regardless of the physical test context, subjects can sometimes imaginally reinstate their input context. Therefore, tests that do not encourage the use of self-generated context cues, such as indirect tests and interference reduction paradigms, are most likely to find context effects. Overshadowing by more salient cues at input can prevent storage of context cues, thus diminishing context effects. Even when context cues are stored, context-dependent effects can be diminished by outshining, when non-contextual cues are used to probe memory. Therefore, tests that provide cues (e.g. recognition) are more likely than tests with few cues (e.g. free recall) to find context effects. The principles of contextual fluctuation, cue overload and decontextualization are also important theoretical principles.

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REFERENCES

Anderson, J.R. and Bower, G.H. (1973) *Human Associative Memory*, Washington, DC: Winston.

Baddeley, A.D. (1982) 'Domains of recollection', *Psychological Review* 89: 708–29.

Balsam, P.D. and Tomie, A. (1985) *Context and Learning*, Hillsdale, New Jersey: Erlbaum.

Baltsch, W.R., Bowman, K. and Mohler, L.A. (1992) 'Music-dependent memory in immediate and delayed word recall', *Memory and Cognition* 20: 21–28.

Bilodeau, I.M. and Schlosberg, H. (1951) 'Similarity in stimulating conditions as a variable in retroactive inhibition', *Journal of Experimental Psychology* 41: 199–204.

Bjork, R.A. and Richardson-Klavehn, A. (1989) 'On the puzzling relationship between environmental context and human memory', in C. Izawa (ed.) *Current Issues in Cognitive Processes: The Tulane Floweree Symposium on Cognition*, pp. 313–44, Hillsdale, New Jersey: Erlbaum.

Blaney, P.H. (1987) 'Affect and memory: A review', *Psychological Bulletin* 99: 229–46.

Bower, G.H. (1972) 'Stimulus-sampling theory of encoding variability', in A.W. Melton and E. Martin (eds) *Coding Processes in Human Memory*, pp. 85–124, Washington, DC: Winston.

Canas, J.J. and Nelson, D.L. (1986) 'Recognition and environmental context: The effect of testing by phone', *Bulletin of the Psychonomic Society* 24: 407–9.

Carr, H.A. (1917) 'Maze studies with the white rat: I. Normal animals; II. Blind animals; III. Anosmic animals', *Journal of Animal Behavior* 7: 259–306.

Craik, F.I.M. and Tulving, E. (1975) 'Depth of processing and the retention of words in episodic memory', *Journal of Experimental Psychology: General* 104: 268–94.

Dulsky, S.G. (1935) 'The effect of a change of background on recall and relearning', *Journal of Experimental Psychology* 18: 725–40.

Eich, J.E. (1980) 'The cue-dependent nature of state-dependent retrieval', *Memory and Cogniton* 8: 157–73.

—— (1985) 'Context, memory, and integrated item/context imagery', *Journal of Experimental Psychology: Learning, Memory and Cognition* 11: 764–70.

—— (1989) 'Theoretical issues in state-dependent memory', in H.L. Roediger and F.I.M. Craik (eds) *Varieties of Memory and Consciousness: Essays in Honor of Endel Tulving*, pp. 331–54, Hillsdale, New Jersey: Erlbaum.

Eich, J.E. and Metcalfe, J. (1989) 'Mood-dependent memory for internal versus external events', *Journal of Experimental Psychology: Learning, Memory and Cognition* 15: 443–55.

Eich, J.E., Weingartner, H., Stillman, R.C. and Gillin, J.C. (1975) 'State-dependent accessibility of retrieval cues in the retention of a categorized list', *Journal of Verbal Learning and Verbal Behavior* 14: 408–17.

Eich, J.M. (1982) 'A composite, holographic, associative recall model', *Psychological Review* 89: 627–61.

Estes, W.K. (1955) 'Statistical theory of spontaneous recovery and regression', *Psychological Review* 62: 145–54.

Fernandez, A. and Glenberg, A.M. (1985) 'Changing environmental context does not reliably affect memory', *Memory and Cognition* 13: 333–45.

Fisher, R.P., Geiselman, R.E., Holland, H.L. and MacKinnon, D.P. (1984) 'Hypnotic and cognitive interviews to enhance the memory of eyewitnesses to crime', *International Journal of Investigative and Forensic Hypnosis* 7: 28–31.

Geiselman, R.E. (1988) 'Improving eyewitness memory through mental reinstatement of context', in G.M. Davies and D.M. Thomson (eds) *Memory in Context: Context in Memory*, pp. 245–66, New York: Wiley.

Geiselman, R.E. and Bjork, R.A. (1980) 'Primary versus secondary rehearsal in imagined voices: Differential effects on recognition', *Cognitive Psychology* 12: 188–205.

Glenberg, A.M. (1979) 'Component-levels theory of the effects of spacing of repetitions on recall and recognition', *Memory and Cognition* 7: 95–112.

Glenberg, A.M., Meyer, M. and Lindem, K. (1987) 'Mental models contribute to foregrounding during text comprehension', *Journal of Memory and Language* 26: 69–83.

Godden, D.R. and Baddeley, A.D. (1975) 'Context-dependent memory in two natural environments: On land and under water', *British Journal of Psychology* 66: 325–32.

—— (1980) 'When does context influence recognition memory?', *British Journal of Psychology* 71: 99–104.

Greenspoon, J. and Ranyard, R. (1957) 'Stimulus conditions and retroactive inhibition', *Journal of Experimental Psychology* 53: 55–9.

Hintzman, D.L. (1986) ' "Schema abstraction" in a multiple-trace memory model', *Psychological Review* 93: 411–28.

—— (1988) 'Judgments of frequency and recognition memory in a multiple trace memory model', *Psychological Review* 95: 528–51.

Jacoby, L.L. (1983) 'Perceptual enhancement: Persistent effects of an experience', *Journal of Experimental Psychology: Learning, Memory and Cognition* 9: 21–38.

Jacoby, L.L. and Witherspoon, D. (1981) 'Remembering without awareness', *Canadian Journal of Psychology* 36: 300–24.

James, W. (1890) *The Principles of Psychology*, New York: Holt.

Kintsch, W. (1974) *The Representation of Meaning in Memory*, Hillsdale, New Jersey: Erlbaum.

Leight, K.A. and Ellis, H.C. (1981) 'Emotional mood states, strategies, and state-dependency in memory', *Journal of Verbal Learning and Verbal Behavior* 20: 251–66.

Macintosh, N.J. (1975) 'A theory of attention', *Psychological Review* 82: 276–98.

Malpass, R.S. and Devine, P.G. (1981) 'Guided memory in eyewitness identification', *Journal of Applied Psychology* 66: 343–50.

Matzel, L.D., Schachtman, T.R. and Miller, R.R. (1985) 'Recovery of an overshadowed association achieved by extinction of the overshadowing stimulus', *Learning and Motivation* 16: 398–412.
Mensink, G.J. and Raaijmakers, J.G.W. (1988) 'A model for interference and forgetting', *Psychological Review* 95: 434–55.
——— (1989) *Journal of Mathematical Psychology* 33: 172–86.
Raaijmakers, J.G.W. and Shiffrin, R.M. (1980) 'SAM: A theory of probabilistic search of associative memory', in G.H. Bower (ed.) *The Psychology of Learning and Motivation: Advances in Research and Theory*, vol. 14, New York: Academic Press.
Richardson-Klavehn, A. and Bjork, R.A. (1988) 'Measures of memory', *Annual Review of Psychology* 39: 475–543.
Schank, R.C. and Abelson, R.P. (1977) *Scripts, Plans, Goals and Understanding*, Hillsdale, New Jersey: Erlbaum.
Shiffrin, R.M. (1970) 'Memory search', in D.A. Norman (ed.) *Models of Human Memory*, pp. 375–447, New York: Academic Press.
Smith, S. and Guthrie, E.R. (1927) *General Psychology in Terms of Behavior*, New York: D. Appleton.
Smith, S.M. (1979) 'Remembering in and out of context', *Journal of Experimental Psychology: Learning and Memory* 5: 460–71.
——— (1982) 'Enhancement of recall using multiple environmental contexts during learning', *Memory and Cognition* 10: 405–12.
——— (1984) 'A comparison of two techniques for reducing context-dependent forgetting', *Memory and Cognition* 12, 477–82.
——— (1985a) 'Background music and context-dependent memory', *American Journal of Psychology* 98: 591–603.
——— (1985b) 'Effects of number of study environments and learning instructions on free recall clustering and accuracy', *Bulletin of the Psychonomic Society* 23: 440–2.
——— (1986) 'Environmental context-dependent recognition memory using a short-term memory task for input', *Memory and Cognition* 14: 347–54.
——— (1988) 'Environmental context-dependent memory', in G.M. Davies and D.M. Thomson (eds) *Memory in Context: Context in Memory*, pp. 13–33, New York: Wiley.
Smith, S.M. and Rothkopf, E.Z. (1984) 'Contextual enrichment and distribution of practice in the classroom', *Cognition and Instruction* 1: 341–58.
Smith, S.M. and Sinha, A.K. (1987) 'Effects of brief immersion in a flotation tank on memory and cognition', Texas A&M University CSCS Technical Report no. 004.
Smith, S.M. and Vela, E. (1986) 'Outshining: The relative effectiveness of cues', presented at the annual meeting of the Psychonomic Society, New Orleans.
——— (in press) 'Environmental context-dependent eyewitness recognition', *Applied Cognitive Psychology*.
Smith, S.M., Glenberg, A.M. and Bjork, R.A. (1978) 'Environmental context and human memory', *Memory and Cognition* 6: 342–53.
Smith, S.M., Heath, F.R. and Vela, E. (1990) 'Environmental context-dependent homophone spelling', *American Journal of Psychology* 103: 229–42.

Stillman, R.C., Weingartner, H., Wyatt, R.J., Gillin, J.C. and Eich, J.E. (1974) 'State-dependent (dissociative) effects of marijuana on human memory', *Archives of General Psychiatry* 31: 81–5.
Thomson, D.M. and Davies, G.M. (1988) 'Introduction', in G.M. Davies and D.M. Thomson (eds) *Memory in Context: Context in Memory*, pp. 1–10, New York: Wiley.
Thorndyke, P.W. (1977) 'Cognitive structures in comprehension and memory of narrative discourse', *Cognitive Psychology* 9: 77–110.
Tulving, E. (1972) 'Episodic and semantic memory', in E. Tulving and W. Donaldson (eds) *Organization of Memory*, New York: Academic Press.
Tulving, E. and Thomson, D.M. (1973) 'Encoding specificity and retrieval processes in episodic memory', *Psychological Review* 80: 352–73.
Tulving, E. and Watkins, M.J. (1974) 'Structure of memory traces', *Psychological Review* 82: 261–75.
Tulving, E., Schacter, D.L. and Stark, H.A. (1982) 'Priming effects in word fragment completion are independent of recognition memory', *Journal of Experimental Psychology: Learning, Memory and Cognition* 8: 336–42.
Vela, E. (1991) 'Environmental context-dependent memory: A cue competition interpretation', presented at the annual meeting of the Midwestern Psychological Association, Chicago.
Vela, E. and Smith, S.M. (1992) 'A meta-analytic review of studies of environmental context-dependent memory effects', unpublished manuscript.
Watkins, O.C. and Watkins, M.J. (1970) 'Buildup of proactive inhibition: A cue overload effect', *Journal of Experimental Psychology: Human Learning and Memory* 1: 442–53.
Wright, D.L. and Shea, C.H. (1991) 'Contextual dependencies in motor skills', *Memory and Cognition* 19: 361–70.