Identifying the locus of repetition priming

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Michael P. Dean

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ABSTRACT

People are able to respond more quickly to stimuli following a recent encounter with those same items. This facilitation in processing a stimulus as a function of a prior encounter is known as repetition priming. This thesis contains eleven experiments that attempt to describe the nature of the representations in memory underlying the effect. Changing aspects of the stimuli and task between the initial encounter and the subsequent test encounter allow examination of the kinds of information contained in these representations.

The effects on repetition priming of recombining the pairings of simultaneously presented items in a speeded same/different matching task were examined (Experiments 1, 2, 3 & 6). Despite priming being insensitive to the pairings of items, subjects were able to recognise this information (Experiment 4), revealing an item-specific locus for the priming effect and a dissociation from explicit memory. Priming was shown to be based on domain-specific and not conceptual information (Experiment 5). Experiments 7 and 8 examined the role of repeating the decision and response to stimuli in producing repetition priming. Results suggested that any such role reflects subjects' use of explicit memory as a basis for responding in the task, rather than reflecting automatic priming effects.

Manipulating the semantic interpretation demanded of a homograph between training and test did not affect repetition priming (Experiment 9). The independent representation of simultaneously presented stimuli did not necessarily depend upon the activation of pre-existing representations or connections (Experiment 10). Experiment 11 revealed a necessary role for the identification of stimuli in producing repetition priming.

The results of these eleven experiments pose problems for accounts of repetition priming based on the retrieval of processing episodes, or the reinstatement of processing demands. The results are consistent with a perceptual locus of the priming effect, based on representations of structure and form employed in the identification of individual stimuli.

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Department of Psychology, 1995.

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DECLARATION

This thesis is the outcome of my own work; none of it is the result of collaboration. No part of this thesis has been submitted in candidature for any other degree or qualification. The copyright of this thesis rests with the author. No quotation from it should be published without his prior written consent and information derived from it should be acknowledged.

Some of this work has been reported elsewhere. Experiments 1-6 were presented at the British Psychological Society Cognitive Section Annual Conference, Cambridge, September 1994, in a talk entitled: "Activation of perceptual representations underlies repetition priming." The same experiments are described in:

> Dean, M.P. & Young, A.W. (in press). An item-specific locus of repetition priming. *Quarterly Journal of Experimental Psychology,* A.

Experiments 9 and 10 are described in:

> Dean, M.P. & Young, A.W. (in press). Repetition priming of homographs and novel objects: Evidence for an item-specific locus. *British Journal of Psychology.*

Experiment 11 was presented at the London meeting of The Experimental Psychology Society, January 1995, in a talk entitled: "When reinstating prior processing demands does not produce the largest repetition effects." The experiment is also described in:

> Dean, M.P. & Young, A.W. (in press). Reinstatement of prior processing demands and repetition priming. *Memory.*

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There is no amusing verse or quotation suitable to preface this work.

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THEORIES OF REPETITION PRIMING

INTRODUCTION

To the layperson, the term "memory test" usually means the recall or recognition of recently experienced events. Performance on these tests requires either a consciously initiated search of memory ("trying to remember something") or at least awareness of automatically retrieved information as having been encountered before (a previously studied item being accompanied by a sense of familiarity). A past encounter with an item can, however, also exert an influence on task performance in the absence of conscious recollection of its prior occurrence. The existence of this distinction between memory with and without conscious awareness has been recognised for some time. For example, Ebbinghaus (1885) reported that after a 24 hour retention interval he was able to relearn a list of nonsense syllables more quickly than he was able to learn a new list, even though he was unable to consciously recollect any of the studied items. He observed that "...vanished mental states give indubitable proof of their continued existence even if they themselves do not return to consciousness at all, or at least not exactly at the given time" (1885/1964, p.2). Writing about a memory impaired subject, suffering from the organic amnesic syndrome that now bears his name, Korsakoff (1889) observed "...although the patient was not aware that he preserved traces of impressions that he received, those traces however probably existed and had an influence in one way or another on the course of ideas, at least in unconscious intellectual activity." (1889, p.512). Korsakoff (1889) interpreted this dissociation between conscious and unconscious aspects of memory as indicating that amnesic patients retained only weak memory traces, sufficient to affect behaviour but not sufficient to enter consciousness. More recently, however, experimental studies on normal subjects have demonstrated functional dissociations between memory in the presence of conscious awareness and memory in the absence of conscious awareness. Different sets of independent variables affect the two types of memory differentially, arguing against the simple trace strength view and suggesting that the two memory phenomena have different functional bases.

The term *explicit memory* was introduced by Graf and Schacter (1985) to refer to the conscious recall and recognition of previously encountered information, and the term *implicit memory* to describe the influence of past events on current performance in the absence of conscious awareness. There has been recent and considerable debate about the utility of these terms (e.g. Dunn & Kirsner, 1988; Gardiner & Java, 1993; Jacoby, 1991). Memory tasks are not necessarily "process pure". Performance on a *direct* test of memory, in which subjects are requested to refer to past events (i.e. recall or recognition), could be mediated by implicit as well as by explicit memory processes. Performance on an *indirect test*, in which no reference to past events is made, but in which those events can still affect performance, could be mediated by explicit as well as by implicit memory processes. Recognising this fact has been an important development in the way perhaps otherwise seemingly contradictory experimental findings have been interpreted.

THE REPETITION PRIMING EFFECT

One implicit memory phenomenon is the repetition priming effect. It is a simple effect to describe; it is less easy to explain. Repetition priming can be defined as the facilitation in the processing of an item (such as a picture of an object or a word) due to a recent encounter with that same item. Repetition priming is therefore a form of memory, reflecting the influence of past experience on current task performance, and as such must depend upon some kind of memory representation stored between the prior and the subsequent encounter. Attempting to describe the exact nature of these memory representations has been the concern of much recent research, as it is of this thesis. It is necessary to distinguish between *repetition* priming and other uses of the term "priming", most notably *semantic* priming effects. The latter can be defined as the facilitation in processing an item when it is preceded by a semantically or associatively related item. Repetition priming and semantic priming have both quantitatively and qualitatively different properties, such as time course (Meyer & Schvaneveldt, 1971) and modality-specificity (Swinney, Onifer, Prather & Hirshkowitz, 1979; Vanderwart, 1984), and different mechanisms have been proposed to account for their occurrence (e.g. Farah, 1989).

The studies of preserved memory in amnesics carried out by Warrington and Weiskrantz (1968, 1970) in many ways represent the start of a modern research interest in repetition priming. Warrington and Weiskrantz (1968) presented subjects with series of fragmented pictures of objects and words in increasing degrees of completeness until they could be identified. When this task was repeated, both amnesic subjects and control subjects were able to identify the stimuli in more degraded forms than was possible at the initial presentation. Warrington and Weiskrantz (1970) found that while amnesics were severely impaired in their recognition and free recall of studied words, they produced these words in response to the first three letters as cues to the same degree as did control subjects. These findings are important because they revealed that completion of a picture- or word-fragment or a word-stem could be facilitated by a prior encounter with an item when that item was not available to aware memory. It is now a robust finding that normal, or near normal, levels of repetition priming can be observed in subjects who are impaired in their performance on direct tests of recognition and recall (e.g. Hamann, Squire & Schacter, 1995). Understanding the properties of repetition priming, and its relations with other forms of memory, are therefore important goals in describing the functional deficit in amnesia.

Performance on repetition priming tasks has also been studied in order to investigate the processes involved in the initial recognition or identification of objects and words. This research has evolved in parallel, to a certain extent, with that concerned with repetition priming as a memory phenomenon and has an equally short history and burgeoning literature. An early landmark was an experiment carried out by Neisser (1954). He found that while identification and naming of a written word (e.g. RAIN) from a brief exposure was facilitated by having read that word aloud before, the identification and naming of a homonym (REIGN) was not facilitated. The repetition effect was therefore attributed to facilitation in the perception of visual patterns, rather than in the production of a response.

Repetition priming is apparent in a large number of different laboratory tasks. For example, repetition effects are seen in the lexical decision task, in which subjects respond as quickly as possible to indicate whether a letter string is a real word or a nonword. Response latencies are faster to words that have been responded to or studied in some earlier phase of the experiment than they are to words not similarly pre-exposed (e.g. Scarborough, Gerard & Cortese, 1979). Priming effects are evident in the perceptual identification task, in which subjects attempt to identify words from very brief (e.g. 35 millisecond) presentations. A greater proportion of words are correctly identified when repeated than words shown only once within the experiment (Jacoby & Dallas, 1981). After having studied a word (e.g. STATION), subjects are more likely to complete a word-stem (STA---) with that word than otherwise, when asked to produce the first word that comes to mind (which could be STATION, STAMP, START etc.) (Graf & Schacter, 1985; Warrington & Weiskrantz, 1970). A variation on word-stem completion uses word-fragment cues, such as ST-T-O- (Tulving, Schacter & Stark, 1982). A number of studies have examined the more fluent, that is, faster, re-reading of text that has been read by subjects on some prior occasion (Carr, Brown & Charalambous, 1989; Kolers, 1975).

Repetition priming is also evident in the perceptual identification of spoken, and not just written, words. A greater proportion of heard words are identified against background noise when they have been heard earlier in the experiment (Gipson, 1986; Jackson & Morton, 1984). When given the spoken first syllables of words as cues, and instructions to complete them with the first word that comes to mind, subjects produce a greater proportion of previously encountered words than would otherwise occur (McClelland & Pring, 1991).

Repetition priming effects have also been observed in tasks requiring the processes of spoken word production, for example, in the identification and naming of famous faces following reading aloud of famous names (Bruce & Valentine, 1985) and in the naming of pictures of objects following names being read aloud or produced from a definition (Wheeldon & Monsell, 1992).

Interest in issues of reading and lexical representation has lead to an emphasis on verbal materials in the repetition priming literature. Facilitation in the processing of nonverbal items also occurs as a function of a prior encounter with those same items. Repetition priming has been reported in the identification of object pictures that are briefly presented (Warren & Morton, 1982) or are degraded (Warrington & Weiskrantz, 1968) and in the naming of depicted objects (Durso & Johnson, 1979; Lachman & Lachman, 1980). In a task analogous to lexical decision, subjects are quicker to indicate whether a drawing is of a real object or a novel object if those items have been responded to earlier in a continuous sequence of trials (Kroll & Potter, 1984). Subjects are also more accurate in deciding whether briefly presented line drawings depict possible structures (that could be realised in three dimensions) or impossible structures (containing surface and edge violations that would prevent them being realised in three dimensions), when a left-facing/right-facing decision was made about the stimuli earlier (Schacter, Cooper & Delaney, 1990).

These different tasks in which repetition priming effects can occur all have the same basic design. There are two phases in the experiment. Stimuli are presented to subjects in the first phase, which is variously described as *study*, *pretraining* or simply *training*. (The latter term is adopted here.) These stimuli, or a subset of them, are then repeated in the second phase of the experiment, which is referred to as the *test* phase. These repeated, or *primed*, items are presented along with *unprimed* items that were not similarly presented during the training phase. Subjects make some response to stimuli in the test phase; repetition priming is revealed by faster or more accurate responding to the primed items than to the unprimed items. It must be noted that the terms "primed" and "unprimed" are used descriptively, referring to whether items at test were presented during training or not. The terms do not reflect whether responding to stimuli is found to be facilitated or otherwise.

Despite the effect being observable only under carefully controlled laboratory conditions, it is important to remember that repetition priming is almost certainly a ubiquitous occurrence in everyday life. It is described as automatic and unconscious, so we are not aware of repetition priming's contribution to our perception of, and memory for, the world around us. Two principal classes of theoretical accounts of the effect can be described, referred to as *episodic* accounts and *item-specific representation* accounts. These will be considered in turn.

EPISODIC ACCOUNTS

The first class of accounts of repetition priming to be considered here views the kind of memory representations underlying the effect as being essentially the same as that underlying performance on other memory tasks, such as direct tests of recognition and recall. This class of theoretical accounts can be described as the episodic accounts, as priming is said to result from the retrieval of records of entire processing episodes.

In a repetition priming experiment, a record of the entire processing event associated with the training phase encounter with an item is said to be stored in memory. This episodic record would therefore include information about the initial perceptual processing of the item, its identification, decision processes based on test instructions and the execution of a response. When repeated in the test phase of the experiment, the item acts as a retrieval cue for the earlier episodic record, and by retrieving the products of the earlier processing, test phase task performance is facilitated (e.g. Hintzman, 1986; Jacoby, 1983a, 1983b; Jacoby & Brooks, 1984; Whittlesea, 1983).

Repetition priming is described as differing from explicit memory only in that it depends to a greater degree upon data-driven processing rather than conceptually-driven processing (Jacoby, 1983a); the two types of memory phenomena do not differ in terms of their basic principles of operation. Data-driven processes are those required for analysis of the physical features of a stimulus, while conceptually-driven processes concern processing of the meaning of a stimulus.

The way in which this class of explanation accounts for the dissociation between performance on repetition priming tests and direct tests of memory is best illustrated with an example. Jacoby (1983a) required subjects either to read target words aloud (e.g. COLD), or to generate those targets from antonym cues (HOT-???). In a subsequent recognition memory test, the generated words were better recognised than the read words. On the other hand, performance on a repetition priming task was superior for the read words than for the generated words: the read words were more likely to be identified from 35 msec tachistoscopic presentations than the generated words. There was, therefore, an interaction between encoding task (generate or read) and type of test (recognition or perceptual identification). Jacoby (1983a) argued that this resulted from the fact that the read condition engaged mainly data-driven processes, i.e. those required for identification of each word from its physical features and its subsequent production, while the generate condition required conceptually-driven processing of the targets - they were produced by virtue of being meaningfully related to the antonym cues and were not identified from their physical features. Attempting to identify words from brief tachistoscopic presentation is a data-driven task; it requires the identification of stimuli from their physical features, and hence words encountered in this test would act as more efficient retrieval cues for words in the read condition at training rather than in the generate condition. The recognition memory test was described as depending more upon conceptually-driven processes, requiring not just identification of the words but also examination of each for some acquired familiarity, or recollection of the context in which each had occurred earlier. Target words in the recognition test would therefore be more successful at retrieving words encountered in the generate condition at training rather than in the read condition.

According to such an episodic account, the closer the match between the stimuli and task performed at training and test, the more efficient the retrieval cue will be, and the greater the repetition priming effect. This account can be seen as an extension of the *transfer appropriate processing* framework described by Morris, Bransford and Franks (1977). They argued that performance on a memory task depends not only upon the processing that is carried out when a to-be-remembered item is encountered at study, but also upon the way in which retention of that item is to be tested. Morris *et al.* (1977) gave subjects a list of words, asking them to answer one of two kinds of question about each. The questions concerned either some semantic property of the word, or whether it rhymed with another given word. Memory for the items was tested, after a delay, in one of two ways: either with a standard recognition test (selecting the studied words and rejecting new, distractor words), or with a rhyming recognition test in which subjects indicated whether a given word rhymed with a studied word or not, the studied words themselves not being presented. Performance on the standard recognition memory test was superior following the semantic encoding task than following the rhyme encoding task. On the other hand, performance on the rhyming recognition task was superior following the rhyme encoding task than following the semantic encoding task. It cannot be said, therefore, that either of the two encoding tasks produced "better memory" for the words in question, rather, performance was determined by the extent to which processing demands at test overlapped with those that occurred in the study phase of the experiment. The transfer appropriate processing framework has also been used to explain the occurrence and properties of repetition priming (e.g. Roediger & Blaxton, 1987a, 1987b; Roediger, Weldon & Challis, 1989). Again, the effect is seen as differing from other memory phenomenon only in that repetition priming tests tend to depend upon the reinstatement of perceptual processing operations, and hence the effect is affected by manipulations of perceptual information rather than conceptual information between training and test.

In summary, according to an episodic account of repetition priming, the representations in memory underlying the effect are of entire processing episodes, there being a unique record of each encounter with any stimulus item. The degree of priming of an individual stimulus item is determined by the match in processing demands associated with that item at training and test encounters.

ITEM-SPECIFIC REPRESENTATION ACCOUNTS

A second class of accounts of repetition priming, described here as item-specific representation accounts, can be contrasted with episodic accounts. Item-specific representation accounts propose a different mechanism by which the effect occurs. The training phase encounter with an item activates, or sometimes creates, that item's representation in a pre-semantic system dedicated to representing individual objects' and words' form and structure for the purpose of identification. Having been activated by the training encounter with an item, reactivation of the same representation is facilitated when that item is encountered at test. Hence the identity an item repeated from training at test is recognised more readily. The memory representations underlying the priming effect contain only information that is important to the identification of stimuli; they do not represent the entire set of processing operations associated with a stimulus.

This class of explanation derives from Morton's (1969, 1979) logogen model of word recognition. Logogens were described as representations of words, together forming a kind of mental lexicon, their being representations of word identity and not meaning. Each word in a subject's vocabulary is represented by a logogen; they can therefore be described as item-specific. When a word is encountered, logogens are activated to varying degrees depending upon how well the sensory input matches the word they represent. When the activation of any one logogen exceeds some threshold value, the stimulus is identified as having the identity associated with that logogen. Only subsequent to this process can semantic information about the stimulus be accessed. The locus of the repetition priming effect is at the level of the logogens; the "firing" of a logogen also results in a long lasting, but slowly decaying, lowering of the activation threshold necessary for recognition. Thus recognition of that same word is facilitated if it is repeated.

Logogens can therefore be considered *abstract* representations of word identity. The representations are not specific to each encounter with a word, as is the case in an episodic account, but instead describe the common content of each encounter. That subjects are able to form abstract representations of central tendency on the basis of encounters with specific exemplars of a class of stimuli has been demonstrated (Posner & Keele, 1968; McClelland & Rumelhart, 1985).

In the original version of the logogen model, the same representation was described as being activated when a word is read or heard spoken; the representations abstract across the modality in which stimuli are encountered. In later versions of the model (Morton, 1979), however, there were separate modality-specific subsystems - a visual input system and an auditory input system - each of which contained its own set of logogens. These representations were still regarded as abstract in nature, not retaining information about surface features such as the font in which words were written (Morton, 1979; Experiment 2); any encounter with a written word would result in its identification being mediated by the same logogen in the visual input system. Murrel and Morton (1974) found identification of a word (e.g. BORED) to be facilitated by a prior encounter with a morphologically related word (BORING) but not with a visually or acoustically similar word (BORN). They argued that logogens in fact represented root morphemes rather than whole inflected words.

Analogous to the logogens that mediate word recognition, representations of object identity have been described in accounts of object recognition. These have been termed "pictogens" (Seymour, 1973; Warren & Morton, 1984). Again, these are deemed to be abstract representations - the same pictogen mediates the identification of all seen dogs, for instance, regardless of their breed, whether sitting or standing or their distance from the viewer. Repetition priming can be accounted for in the same way as with words, that is by the activation of an item-specific representation facilitating its subsequent activation and hence facilitating subsequent identification of that same object.

Not all variants of the item-specific representation class of accounts deem that pre-existing representations of abstract word or object identity underlie the effect. There are many examples of repetition priming occurring for nonwords (e.g. Scarborough, Cortese & Scarborough, 1977; Feustel, Shiffrin & Salasoo, 1983) and for novel objects (e.g. Kroll & Potter, 1984; Schacter *et al.*, 1990); therefore the representations underlying the effect cannot *only* be pre-existing stored representations of word or object identity. There is evidence to suggest, however, that priming of nonwords and novel objects may result from the facilitated reactivation of pre-existing sub-lexical or sub-object representations. Dorfman (1994) found priming only of nonwords constructed from familiar morphemic and syllabic structures. Schacter *et al.* (1990) found priming only of structurally possible, but not impossible, figures. If novel stimuli are represented in terms of pre-existing sub-lexical and sub-object components, they are still represented in terms of novel *combinations* of these components. A new representation must be created after a single encounter with a novel object and this must be able to support repetition priming when that item is repeated. Tulving and Schacter (1990) argue that "hyperspecific" (i.e. specific to each stimulus used, regardless of its abstract identity) access to stored representations may underlie priming even with familiar words. Their account is a variant of the item-specific representation class of accounts because the representations underlying the priming effect are deemed to be those that underlie the identification of individual stimuli; they are not representations of entire processing episodes.

Within the item-specific representation class of accounts there are other differences. A number of mechanisms by which the activation of a representation of an item could result in the subsequently facilitated activation of that same representation have been described. In Morton's (1969) model of word recognition, the "firing" of a logogen results not only in the identification of a stimulus, but also in a lowering of the activation threshold necessary for identification. Thus recognition of that same word is facilitated if repeated. McClelland and Rumelhart (1981) modelled the effect as resulting from an increase in the resting level of activation of a word recognition unit, rather than a change in its threshold level of firing, in their interactive activation account of word recognition. Monsell (1991) suggested that repetition priming results from changes in the weights of connections between word recognition units and other representations (orthographic, phonological, semantic) rather than changes within the units themselves. So, for example, repetition priming occurs due to changes in the connections between perceptual representations ("face recognition units") and conceptual representations of that person's identity ("person identity nodes") in Burton, Bruce and Johnston's (1990) interactive activation model of face recognition. These possible mechanisms (and any others) are subsumed under the term *activation* here although, technically speaking, *identification* results from the activation of an item-specific representation and repetition priming results from some change that *facilitates* subsequent activation of that representation. To use the term activation is to remain neutral as to the specific mechanism by which this facilitation occurs.

It would be difficult to discuss cognitive psychology in 1995 without mentioning a connectionist, or parallel distributed processing, account of the effect under scrutiny. The architecture for a connectionist account (e.g. Hinton & Anderson, 1981; McClelland & Rumelhart, 1985) consists of a number of units, each connected to others to form a network. Each unit can be activated and contributes to, or inhibits, the activation of the units to which it is connected. With the presentation of an input to the network (e.g. a word or an object) there develops a stable pattern of activation over the entire network as a result of dynamic interactions between the units, and hence the notion of *distributed* representations rather than the focal representations of, for example, the logogen account. The stable pattern of activation reached represents the interpretation of the input that maximally satisfies the constraints imposed by the weights on connections between the units. There follows an adjustment of the connection weights, dependent upon the present pattern of activation. The processing of an item therefore affects the way in which all subsequent items are processed, and will facilitate the categorisation (identification) of that same item if it is repeated. That this occurs is perhaps best understood not in terms of a verbal description, but rather as evidenced in simulations carried out using connectionist networks (e.g. Hummel & Biederman, 1992; McClelland and Rumelhart, 1985).

An account of repetition priming based on a parallel distributed processing model of word recognition or object recognition can be regarded as a member of the item-specific representation class of accounts. This is despite the fact that in such distributed models there are no discrete representations of individual items. As Broadbent (1985) pointed out, to describe discrete representations as underlying priming at a molar level does not preclude a distributed architecture as a molecular account of the effect. The way in which a distributed network represents an item is in terms of a pattern of activation that is determined by the weights on connections between units, and these weights have themselves been determined by the network's prior experience with stimuli. A trace of each encounter with a stimulus, independent of memory traces of all other encounters, is not laid down as in an episodic account.

According to an item-specific account of repetition priming, the dissociations between performance on priming tests and direct tests of recognition and recall result from the fact that the tests tap different memory systems. While repetition priming results from the operation of a perceptual representation system, there is also an episodic memory system which encodes information other than that pertinent to stimulus identification and which mediates conscious uses of memory. The two memory systems are usually described as being anatomically distinct, and hence can be selectively impaired by neurological insult. The distinction between the memory systems has been expressed in a number of ways (Cohen & Squire, 1980; Tulving, 1983; Tulving & Schacter, 1990; Weiskrantz, 1987); the distinction is phrased here in terms of whether the representations underlying priming are of individual stimuli (item-specific representation accounts) or are of entire processing episodes (episodic accounts). This distinction is a useful one to make because, as will be explained, there are circumstances in which the two classes of account make different predictions.

MUTUALLY EXCLUSIVE?

While the two classes of account propose different mechanisms by which repetition priming occurs, they are not necessarily mutually exclusive. It may be that under different conditions, that is, in different tasks, there are different bases for repetition priming. It may also be the case that *within* a repetition priming experiment, the facilitated processing of repeated stimuli results in part from the activation of item-specific representations, and in part from the retrieval of the prior processing episode associated with that item. This point has been stressed by Monsell (1991; Wheeldon & Monsell, 1992). In different tasks there is likely to be a different balance between the relative importance of these two sources of facilitation. What *are* mutually exclusive, however, are strong versions of each claim, for example that the activation of stored representations of known words or objects is the only locus of the effect, or that word and object recognition proceeds via the retrieval of specific prior encounters with those items.

MAKING CHANGES BETWEEN TRAINING AND TEST - A BRIEF REVIEW

Much of the research on repetition priming has advanced by changing aspects of the stimuli and of the task performed between the training phase and the test phase in an experiment. By examining which kinds of manipulations affect priming, and which do not, one can investigate the kinds of information that enter into the representations underlying the effect, and hence learn something about the mental representation of words and objects and the organisation of memory. There follows a necessarily brief and selective review of this literature.

Studies in which changes are made to physical characteristics of the stimuli themselves are considered first. Without wanting to presage discussion of these studies, both episodic and item-specific representation accounts have developed to be able to accommodate many of the clearly established empirical characteristics of repetition priming in this regard. It is illustrative to see how they are able to do so. Where reliable results remain that pose problems for one particular class of accounts, they often occur in the context of other seemingly conflicting (and reliable) evidence.

Experiments have also been performed which examine the effects of changing the task to be performed between the training and test phases. Stimuli can be repeated from training at test, but subjects be instructed to base their responses on different decisions about the stimuli. There are also studies which examine the effects of changing the context in which stimuli are presented. Context, in this context, usually refers to other stimuli that accompany those items under scrutiny. These studies more directly address the distinction between episodic and item-specific representation accounts of repetition priming, as this distinction rests on whether information other than that involved in the *identification* of individual stimuli enters into the representations underlying the effect. The context in which an item occurs, or its interpretation in terms of task demands, need not affect its identification, yet is implicated in the processing episode associated with that item. Again, there are many seemingly conflicting results and their interpretation is contentious.

CHANGING THE STIMULI

PRIMING ACROSS MODALITIES AND DOMAINS

The degree to which the processing of an item is facilitated by repetition is reduced by a change in the sensory modality in which it is presented. This finding has been reported with different combinations of the modality in which stimuli are presented in the training and test phases of each experiment, and with a variety of repetition priming tasks. There is less (but still significant) priming of visually presented words in stem completion, degraded word identification, word-fragment completion and lexical decision tasks following auditory presentation of words at training than following visual presentation of those words (Graf, Shimamura & Squire, 1985; Hashtroudi, Ferguson, Rappold & Chrosniak, 1988; Roediger & Blaxton, 1987b; Scarborough *et al.*, 1979). Jacoby & Dallas (1981) report no significant priming in the identification of briefly presented words following auditory, as opposed to visual, presentation of the words at training. Conversely, Jackson and Morton (1984) report less priming in the identification of spoken words against noise following visual presentation of the words at training than following auditory presentation of the words. Bassili, Smith and MacLeod (1989) found less priming of the completion of auditory word-stems when repeated items had been seen as written words at training than when they had been heard.

Repetition priming is also moderated by changes in the representational domain within a modality in which stimuli are presented, between training and test. For example, Winnick and Daniel (1970) found only the naming of written words to prime subsequent tachistoscopic identification of those words, and not the naming of the words in response to pictures or definitions at training. Similarly, less priming of written words in a lexical decision task occurs when items have been named from object pictures rather than words at training (Scarborough *et al.*, 1979). There is less facilitation of latency to name pictures, of accuracy in identifying briefly presented pictures and naming picture fragments when stimuli are presented as written words at training than when they are presented as pictures (Durso & Johnson, 1979; Warren & Morton, 1982; Weldon & Roediger, 1987). Bruce and Valentine (1985) found less facilitation of the identification of briefly presented famous faces when written names of the famous people had been presented at training rather than the faces themselves. When the test phase task was one of making speeded familiarity decisions, no cross-domain priming at all was observed.

Theoretical accounts that fall within both of the classes outlined above can accommodate the modality- and domain-specificity of repetition priming. According to an episodic account, the closer the match in the processing demands when an item is encountered at training and at test, the more efficient a retrieval cue the test encounter will be for the training encounter, and the greater the benefit to processing the item at test. Any change in processing demands between training and test will attenuate the priming effect. Changes in the modality or domain in which items are presented require some changes in the set of processing operations performed at training and test, and thus these changes attenuate the priming effect. The fact that significant, but reduced, priming remains in some tasks following such changes (e.g. word-fragment completion; Hirshman, Snodgrass, Mindes & Feenan, 1990) but is eliminated in others (e.g. perceptual identification; Jacoby & Dallas, 1981) is explained by a closer examination of the processing demands of each task. Changes in modality or domain affect only the perceptual, or data-driven, processing of stimuli; they do not affect conceptually-driven processing. Tasks are described as varying in the degrees to which they require data-driven and conceptually-driven processing. Priming in tasks with a significant conceptually-driven component, such as word-fragment completion, will be attenuated less by changes in modality or domain than priming in tasks which are to a larger extent data-driven, such as perceptual identification (e.g. Roediger *et al.*, 1989). It is not entirely clear, however, how the relative importance of data-driven and conceptually-driven processing in different tasks can be described without resorting to circular arguments, although the idea that some tasks differ in this respect is at least intuitively valid.

According to an item-specific representation account, there is reduced or absent cross-modal and cross-domain priming because different representations are employed for the recognition of heard words, read words and pictures. Morton (1979) made this change to his earlier (e.g. 1969) version of the logogen model in response to findings, particularly those of Winnick and Daniel (1970), of modality- and domain-specific priming. While in the earlier version of Morton's model the same logogen was responsible for the identification of all encounters with a known word, the model was modified to include an auditory input system and a visual input system, containing their own sets of logogens, to mediate spoken and written word recognition. A picture recognition system was also described. Tulving and Schacter (1990) described the perceptual representation system (PRS), comprising the independent word form system and structural description system. When an item is encountered at training, the representation dedicated to its perceptual structure and form will be activated or perhaps formed; performance of a task at test will benefit if that same modality- and domain-specific representation is re-employed. Importantly, there is independent evidence for the existence of these sub-systems; they can be selectively impaired by neurological insult (e.g. Ellis & Young, 1988).

There are two main ways in which the finding of reduced but still significant priming following changes in modality and domain can be accommodated by an item-specific representation account. Firstly, while the activation of perceptual representations used for the initial identification of stimuli may be *one* locus of the priming effect, it is not necessarily the *only* locus. There is evidence that the activation of item-specific representations employed in spoken word output can also produce facilitation in the naming of stimuli (Bruce & Valentine, 1985; Wheeldon & Monsell, 1992). These representations are not modality- and domain-specific as the same spoken word form is produced in a naming task in response to a written word, a picture or in repeating a heard word. It follows that a change in the modality or domain in which stimuli are presented will attenuate priming on tasks that require only stimulus identification (e.g. familiarity decisions; Bruce & Valentine, 1985; Experiment 2) to a greater extent than on tasks that also involve the naming of stimuli (e.g. Bruce & Valentine, 1985; Experiment 1).

A second way in which an item-specific representation account can accommodate findings of significant, though reduced, cross-modal or cross-domain priming is by recognising that priming tasks are not necessarily "process pure". While priming tasks can be described as indirect tests of memory, in that they do not *require* subjects to consciously recollect past events, it is possible that in some circumstances subjects are doing so. Tests in which explicit memory is used as a basis for responding are likely to be those in which there are no time constraints upon subjects' responding, such as word-stem or word-fragment completion. Explicit memory is less likely to serve as a basis for responding in speeded tasks. As performance on tests of recall or recognition memory is not affected by the manipulation of the modality or domain in which stimuli are presented (Jacoby & Dallas, 1981; Kirsner, Milech & Standen, 1983), it follows that there should be greater preserved priming in some tasks (e.g. word-fragment completion) than others (e.g. perceptual identification). This is as seen (e.g. Hirshman *et al.*, 1990; Jacoby & Dallas, 1981). Such cross-modal or cross-domain priming does not reflect the operation of memory processes that dissociate from those that mediate performance on direct memory tests.

WITHIN-MODALITY AND WITHIN-DOMAIN CHANGES IN SURFACE FORM

Changes can be made to stimuli between training and test encounters while retaining both the identity and the modality and domain in which the items are presented. These changes can be described as affecting the "surface form" of stimuli; they include manipulations of the font in which a word is presented, the orientation of text, the specific exemplar of an object presented, or the angle at which it is viewed. Again, there are many seemingly contradictory results in the literature. Evidence concerning the priming of words is considered first, then the priming of non-verbal stimuli.

Using word stimuli, Kolers (1973) found greater facilitation in the re-reading speed of upside down text when first encountered upside down rather than upright. Similarly, Masson (1986) obtained large effects of changing the case of items upon priming in the re-reading of mirror inverted words. Roediger and Blaxton (1987b) found less priming of typed lower case words in a fragment completion test if they had been handwritten in upper case at training rather than typed, and less priming of the handwritten words at test if typed at training rather than handwritten. With degraded stimuli, specificity of priming to the exact form of the items has been observed. Gardiner, Dawson and Sutton (1989) found more priming in word-fragment completion when the same fragment had been presented at training than when a different fragmented version of that word had been presented.

These results are consistent with an account of the priming effect based on the retrieval of prior processing episodes. Changes in surface form between training and test, such as the font or orientation of an item, should reduce the magnitude of the repetition priming effect as they alter the demands of at least the earliest stages of perceptual processing of that item. These perceptual attributes provide the first set of cues to initiate retrieval. The test encounter with an item will, therefore, act as a less efficient retrieval cue for the training phase encounter with that item following such a change, as compared to when no such change occurs. According to episodic accounts of the priming effect, it is this retrieval of the entire prior processing episode associated with an item that results in the facilitation of test task performance.

There are various ways in which these results can be accommodated by item-specific representation accounts of the repetition priming effect. Findings of sensitivity of priming to variations in surface form pose clear problems for accounts such as Morton's (1969, 1979) logogen model, in which priming is described as resulting from the facilitated use of an abstract representation of a word (or some root morphemic structure; Murrel & Morton, 1974). According to this model, a logogen devoted to visual input is activated by all instances of that written word regardless of orientation, font, case and so forth. Repetition priming should therefore be insensitive to changes in surface form. An item-specific representation account, however, does predict effects of changes in surface form if it assumed that the representations underlying the effect have the properties of "distributed memories" (McClelland & Rumelhart, 1985), both abstracting from each encounter with stimuli, and retaining some sensitivity to each individual encounter.

A second way in which an item-specific account can accommodate the findings of sensitivity of priming to variations in surface form described above is if it is argued that explicit memory serves as a basis for responding. The memory representations underlying explicit recognition or recall of the stimulus materials are known to encode information about surface form of words (Hintzman & Summers, 1973; Kirsner, Dunn & Standen, 1987) while those underlying priming in the absence of explicit memory might not. Consistent with this argument, the studies in which sensitivity of priming to changes in surface form have been observed have tended to employ tasks in which explicit memory is most likely to play a role - re-reading speed of text and word-fragment completion in the examples given above. Performance of both tasks could potentially be affected by subjects' recollection of having encountered the stimuli before, although it must be noted that Kolers (1976) found surface form specific facilitation in re-reading speed a year after the training encounter, when subjects were unable to remember the studied text.

A number of experiments have revealed asymmetries in repetition priming following changes in surface form. In Kolers' (1973) study, while there was evidence that the reading of upside down text was facilitated more by having read the text upside down at training rather than upright, there was less evidence for an effect of surface form on priming when the text was upright at test. Brown (1990) found reduced facilitation of reading speed of handwritten text when it was presented typed at study rather than also handwritten, but there was no such specificity effect when the test words were typed. In this case, there was as much facilitation from either surface form at training. Similarly, Brown and Carr (1993) found an effect of changing from handwritten to typed forms in both naming latency and lexical decision tasks with handwritten words at test, but no such specificity to typed words at test. So, when an effect of change in surface form has been reported, it seems to depend to a large part upon the degree of familiarity the subject has with the forms in question. Consistent with this view, Jacoby and Hayman (1987) found that the difference in facilitation between cross- and within-case repetition was greater with highly stylised and unusual fonts than with common fonts. Horton and McKenzie (1995) found no effect of changing the case of words on facilitation of reading speed in three experiments; they did in a fourth when a less legible font was used. This evidence suggests that if the retrieval of prior processing episodes does play a role in producing repetition priming, it is when exceptional demands are placed on perceptual encoding mechanisms. It is then an empirical question as to whether this episodic retrieval reflects subjects' use of explicit memory or otherwise.

Not all studies, however, have found sensitivity of repetition priming to variations in surface form. For example, Clarke and Morton (1984) found no attenuation of priming in the identification of briefly presented words following changes between handwritten and typed words at training and test. Levy and Kirsner (1989, Experiment 2) and Carr *et al.* (1989) found the same pattern of results in the speed to re-read text. Similarly, Scarborough *et al.*, (1977) reported no effect upon priming in a lexical decision task of changes in the case of words between training and test. Rajaram and Roediger (1993) reported no effect of changing the font in which stimuli were presented on priming in tests of fragment completion, stem completion, perceptual identification and anagram solution. These results are consistent with the representations underlying the effect being of the *identity* of each item and not retaining information about each item's surface form. Such results are problematic for episodic accounts which argue that the entire set of processing operations associated with an item are stored together in the representations that underlie repetition priming. It is possible to construct an episodic account, however, in which information abstracted across some dimension can be derived at the time of retrieval from a set of stored processing episodes (Semon, 1909/1923; Hintzman, 1986).

Evidence from studies of non-verbal priming is similarly mixed. Jolicoeur (1985) found priming of the naming of pictures of objects to be reduced by a rotation of the stimulus in the picture plane between training and test. Ellis, Young, Flude and Hay (1987) found most priming of speeded familiarity decisions to pictures of faces when the same picture was shown at both training and test, less priming when a similar picture of the same person was presented at test, and less still when a less similar view of the same person was presented. Bartram (1974) found most facilitation in the naming of an identical photograph of an object, there being reduced priming of photographs depicting different rotations in depth. There was still less priming again of naming a different exemplar of the same object (a picture of an item that has the same name). Warren and Morton (1982) found tachistoscopic identification of objects to be facilitated most following repetition of identical pictures; there was a non-significant trend for priming of different exemplars of the objects. Increasing the length of the study list and testing only a small proportion of study list items resulted in this effect becoming statistically significant. Warren and Morton attributed the reduced priming of the different exemplars to subjects' use of explicit memory strategies; if subjects were identifying items at test on the basis of a match between those items and explicit memory of the trained items, then the lack of a match occurring for the different exemplars would be expected to inhibit their identification. This use of an explicit memory strategy was described as being affected by the manipulation of list length and proportion of stimuli repeated, with automatic priming effects being unaffected. It must be noted, though, that the priming of different exemplars remained smaller in magnitude than that of identical pictures repeated from training at test; a finding that could reflect residual use of an explicit memory strategy or sensitivity of repetition priming to the change in the particular exemplar presented.

Srinivas (1993) found that priming of the identification of fragmented pictures was maximal when the same fragment was seen at training and test rather than when a different fragment, or even the whole picture, was seen at training. This finding of specificity to the exact degraded form is similar to that of Gardiner *et al.* (1989) using word-fragments, and is consistent with the notion that priming is mediated by a representation of the specific nature of a degraded stimulus, rather than a representation in terms of object parts.

These results are consistent with the predictions of an episodic account of the repetition priming effect. According to such an account, a record of the entire processing episode associated with the training phase encounter with an object (or face) is stored in memory. When encountered at test, the stimulus acts as a retrieval cue for the earlier processing episode. The test phase processing of that item is facilitated by the retrieval of the products of the earlier processing. An episodic account predicts that any change in the processing demands associated with an item, between training and test, will result in the test phase encounter acting as a less efficient retrieval cue for the training phase encounter, and will therefore result in less facilitation in processing that item. The changes in surface form (a rotation in depth or the particular version of a fragmented object picture used, etc.) result in changes in processing demands.

There are a number of ways in which an item-specific account can accommodate these findings of sensitivity of priming of objects to changes in the surface form, as there were in the case of word stimuli. Firstly, it is possible that subjects explicitly recall items from training, or recognise them as having been repeated at test, and use this memory as a basis for responding at test. Changes in surface form such as size and rotation in depth, are known to affect explicit memory performance (Rock & DiVita, 1987; Rock, DiVita & Barbeito, 1981; Biederman & Cooper 1992; Cooper, Schacter, Ballesteros & Moore, 1992) and would therefore be expected to affect the priming measure if explicit memory was used as a basis for responding.

Secondly, tasks such as the identification of fragmented pictures of objects may place exceptional demands on perceptual encoding mechanisms. Under these circumstances, retrieving prior processing episodes, whether intentionally or otherwise, may be the least demanding or time consuming way to identify the stimuli. These exception demands may not usually enter into the identification of objects in everyday life.

Not all the evidence for sensitivity of priming to variations in surface form is of this sort (e.g. Ellis *et al.*, 1987). Such sensitivity is predicted if the representations involved are deemed to be distributed memories. Information from individual encounters with stimuli is superimposed, meaning that some sensitivity to individual encounters is retained without the representations necessarily being of entire processing episodes; rather they retain information about structure and form pertinent to the task of stimulus recognition (Ellis *et al.*, 1987; McClelland & Rumelhart, 1985). Sensitivity to rotations in depth is also predicted by some accounts of object recognition, in which identification proceeds by the translation of an item-specific representation to match a stored viewpoint-specific representation (e.g. Tarr & Pinker, 1989; Ullman, 1989). This kind of evidence, then, does not necessarily address the distinction between episodic and item-specific representation classes of accounts.

These findings can be contrasted with those of other studies in which invariance of repetition priming to changes in surface form has been observed. Biederman and Cooper (1991a, 1992) report no deleterious effects of changing the left/right orientation or the size of objects between training and test on the priming of time to name pictures. Cooper *et al.* (1992) found similar invariance to changes in left/right orientation and size in priming of accuracy of possible/impossible decisions made to briefly presented novel structures. In both studies, these same manipulations were found to have effects on recognition memory for the stimulus items. Biederman and Cooper, and Cooper *et al.* concluded that information about the size and left/right orientation of an object is not stored in the representations that underlie repetition priming.

Biederman and Gerhardstein (1992) found no effect of changing the angle in depth at which an object was viewed upon priming of naming briefly presented objects, as long as such a change did not alter the description of the object in terms of structural primitives ("geons"; Biederman, 1987). When the description of the object was altered in terms of these primitives, the priming effect was attenuated. These structural descriptions are therefore specific to the particular stimulus, and represent the individual item prior to addressing some stored representation of identity.

Biederman and Cooper (1991b) examined the effects of changing the exact way in which stimuli are degraded upon priming of the identification of those degraded stimuli. They produced one kind of fragmented object by deleting alternate lines in drawings; a second kind was created by deleting alternate convex components (loosely corresponding to "object parts"). Each fragment had a complement in which the alternative set of alternate lines or components was deleted. For the first kind of stimulus, there was as much priming of the complementary fragments as of the identical fragments when repeated at test. For the second kind of stimulus, there was greater priming of the identical fragments at test than of the complementary fragments. Again, this result was taken as evidence that priming is only attenuated by a change between training and test when a change in the description of the object in terms of certain structural primitives occurs. When alternate lines are deleted, the prime and its complement are still described by the same set of structural primitives and the relations between these primitives. When whole components are deleted, the prime and its complement do not share structural descriptions.

These findings of invariance of the priming effect to changes in surface form are consistent with an item-specific representation account of the priming effect. Whether or not a variable affects the priming effect depends upon whether this information is relevant to the task of stimulus identification. For example, rotations in depth do not affect priming until they also result in a change in the description of the object in terms of its parts; left/right reflections have no affect upon priming because they are irrelevant to identification of the stimulus. Such findings of invariance are problematic for episodic accounts of the priming effect, unless specific mechanisms for the abstraction across a certain feature from the retrieved products of the entire pool of stored episodes are additionally specified (Hintzman, 1986).

SUMMARY

This brief review of repetition priming studies in which perceptual aspects of stimuli have been manipulated has highlighted a number of important points. There is evidence supporting both invariance and sensitivity of the effect to changes in surface form. When sensitivity has been observed, the possibility that subjects used explicit memory as a basis for responding in the test phase has not always been eliminated. Sensitivity also tends to occur when subjects are required to identify perceptually degraded stimuli, and might reflect the operation of perceptual processes not commonly employed in word and object recognition. Finally, sensitivity of priming to changes in surface form is not incompatible with an item-specific account if the memory representations involved are deemed to be distributed representations of individual stimuli, or are descriptions of individual stimuli constructed prior to addressing some stored (abstract) representation of identity.

Whether other, non-perceptual, aspects of the processing episode associated with a stimulus are represented together in the memories that underlie repetition priming is addressed in the following sections.

CHANGING THE TASK

According to an item-specific account, information about aspects of a task that are performed subsequent to stimulus identification, such as decisions made on the basis of task instructions and the selection and execution of a response, are not encoded in the representations that underlie repetition priming. Having performed a different task when stimuli were first encountered should not, therefore, attenuate the degree to which responding to those items is facilitated at test, as compared to having performed the same task at training as at test. An episodic account makes different predictions; it is the reinstatement of the entire processing event that mediates the effect. When an item is repeated at test, any change in the decision made about it, or the selection and execution of a response on the basis of that decision, will mean that the item will act as a less efficient retrieval cue for its training encounter and repetition priming will be attenuated.

Chapter 4 of this thesis contains two experiments which examined the effects of changing the decision and response made to stimuli between training and test. Chapter 7 contains an experiment that examined the role of identification of the stimuli in the effects of changing task performed between training and test. Full discussion of the literature concerning the effects of changing task will therefore be reserved until introduction of those experiments. To summarise here, there is little evidence that changing the task performed between training and test affects the magnitude of repetition priming observed (e.g. Ellis, Young & Flude, 1990; Valentine, Moore, Flude, Young & Ellis, 1993) unless such changes also affect whether just identification or both identification and naming of stimuli are required for task performance (e.g. Durso & Johnson, 1979; Lachman & Lachman, 1980). These results are consistent with there being an item-specific locus of repetition priming in the identification of stimuli, and a second locus in the production of spoken word forms. The representations underlying priming need not contain information about the task-specific interpretation of stimuli.

CHANGING THE CONTEXT

Jacoby (1983b) found that the magnitude of repetition priming was affected by the ratio of repeated (primed) to new (unprimed) items at test, this ratio being described as "the proportion overlap". The degree of facilitation of perceptual identification for repeated items was greater when they constituted 90% of the test items than when they constituted only 10%. It was argued that this resulted from the fact that in the 90% condition each item was presented in a context that was more similar to its training occurrence than in the 10% condition. Jacoby argued that the processing episode includes the context in which an item is presented. As proportion effects also occur in recognition memory (Jacoby, 1972; Todres & Watkins, 1981), this similarity was taken as support for the notion that repetition priming and recognition memory both depend upon the retrieval of prior processing episodes.

This similarity, however, could also reflect the fact that subjects were using explicit memory for the trained items as a basis for responding in the identification task. This possibility is perhaps all the more likely in Jacoby's (1983b) study because subjects in the high proportion group were told of the relationship between trained items and test items, while those in the low proportion group were not. Allan and Jacoby (1990), however, retaining this confound, found that the proportion overlap manipulation did not differentially affect perceptual identification of words that had previously been generated as answers to anagrams, or simply read. As the generated words were better *recognised* than the read words, if the proportion effect was due to the use of explicit memory, it should have affected the generated words more.

An account based on the activation of item-specific representations used for the identification of stimuli would not predict the proportion overlap effect (in the absence of a contribution from explicit memory). The fact that a large or a small number of the other items in the test phase of the experiment have been seen before is irrelevant, according to such accounts, to the identification of the item on a particular trial; contextual information is deemed not to be encoded in the representations underlying repetition priming. Consistent with this position, Jacoby's result has proved difficult to replicate. Challis and Roediger (1993) varied the proportion of items at test that were repeated from training at five levels between 0 and 100% in a word-fragment completion test. There was no effect at all of this manipulation on the repetition priming observed.

There are other ways in which context can be manipulated. Dixon and Rothkopf (1979) had subjects search through text for nonwords. There was as much facilitation of search speed upon repetition of the task with scrambled as with preserved word order. Here word order determined the context in which each individual word in the passage occurred. Again there is contradictory evidence: Levy and Begin (1984) found greater priming effects with preserved word order in a similar task. Carr *et al.* (1989) found no effect on the degree of facilitation of speed to re-read text following scrambling of word order, while Whittlesea (1990) did. Monsell and Banich (1983) reported that priming of lexical decisions made to isolated target words was greater if words were studied in isolation rather than as part of a sentence. Levy and Kirsner (1986) found similar results using a perceptual identification test.

Circumstances have even been described in which a change in the context in which an item appeared, between training and test, produced *more* facilitation in the processing of that item than when there was no change. Levy and Burns (1990) found reading intact, coherent text at training to produce greater facilitation in reading speed of sentence-reordered text at test than reading the sentence-reordered text itself at training.

Changing the room in which testing occurred, the experimenter, the computer used and the presence or absence of background music between training and test have all been found to have no effect on the degree of priming in perceptual identification (Jacoby & Witherspoon, 1982).

A number of studies have manipulated the context in which a stimulus appears by presenting *pairs* of items at training, then repeating these items at test either paired as at training, or re-paired to give novel combinations of items. In a recombined stimulus pair, the context in which each item occurs (its partner) is changed between training and test. The amount to which processing of these stimuli is facilitated can be compared to the amount to which that of stimulus pairs repeated intact is facilitated, to reveal any contribution of the novel associations between items to repetition priming. This logic is also employed in seven of the eleven experiments reported in this thesis; therefore the discussion of this literature below will also serve as an introduction to the first experiment contained in the next chapter.

RECOMBINING THE PAIRINGS OF ITEMS BETWEEN TRAINING AND TEST

The cued word-stem completion task was developed by Graf and Schacter (1985) and has been used extensively since to examine the repetition priming of novel associations. Subjects were initially presented with pairs of unrelated words (e.g. WINDOW-REASON, MOTHER-CALENDAR). They were subsequently required to complete word-stems (e.g. REA...) with the first word that came to mind and were told that an accompanying cue word might help them think of a completion. Each stem could be accompanied by the cue with which it was paired at training (WINDOW-REA...), or with the cue that accompanied another item at training (MOTHER-REA...). A repetition priming effect was revealed in more stems of words seen at training being completed with those trained words (REA... being completed as REASON, rather than READING or REALITY etc.) than otherwise (rate of completion of stems with target words when not similarly presented at training). Priming of the *novel association* between words was revealed in a greater priming effect to stems accompanied by their trained cue (WINDOW-REASON) than stems accompanied by a cue seen at training, but not with that item (MOTHER-REASON). The priming of novel associations reveals an effect of the context in which each item occurs, namely its partnership. Such an effect, therefore, reveals the representations underlying repetition priming not to be item-specific, but rather to contain information about the processing episode in which stimuli occurred at training.

Performance on this indirect test of memory was found to dissociate from performance on a direct test of recall of the same information. Priming of the novel associations was found to be attenuated by a change in the modality in which word pairs were presented between training and test, whereas recall was not (Graf & Schacter 1989). Using items in more than one stimulus pair produced both proactive and retroactive interference in recall of the novel associations, whereas this manipulation did not affect priming of the novel associations (Graf & Schacter, 1987). These results suggest that the novel associative priming effects are mediated by newly formed episodic representations, but different ones from, or at least different components of, those that mediate performance on direct tests of memory.

However, priming of novel associations was found to occur only when subjects had engaged in semantic elaboration when stimuli were encountered at training, for example, if sentences that linked the two members of a pair were generated, or if given sentences were rated for the degree to which they related the words in a pair. Counting vowels in the word pairs, reading the words in meaningless sentences, and rating the pleasantness of the words did not result in priming of the novel associations being evident in the cued stem completion task at test (Graf & Schacter, 1985; Schacter & Graf, 1986). In this respect, repetition priming of the novel associations is unlike repetition priming of single familiar words, which does not appear to depend upon elaborative processing being performed at training (e.g. Jacoby & Dallas, 1981).

A number of studies that have described significant repetition priming of novel associations in normal subjects using this task have been primarily interested in whether the effect is preserved or impaired in subjects with organic amnesia. An important piece of information in characterising these patients' functional deficit is the status of repetition priming of information acquired after the onset of amnesia (see, e.g., Schacter, 1992a). Evidence has been mixed, with some authors reporting robust priming of novel associations in amnesic patients (Graf & Schacter, 1985; Cermak, Blackford, O'Connor & Bleich, 1988) and others finding no evidence for the effect (Mayes & Gooding, 1989; Cermak, Bleich & Blackford, 1988).

Interpreting this mixed evidence is perhaps made easier when it is understood that these studies confound the status of the priming effect in amnesics with the extent to which explicit memory can contribute to performance on the cued stem completion task. While control subjects do show sensitivity to novel associations between items on this task, they have both the automatic memory processes deemed to underlie repetition priming and explicit memory processes available to them. When priming of the novel associations between items has been reported, the effect tended to occur only in patients with less severe explicit memory deficits (Schacter & Graf, 1986; Shimamura & Squire, 1989). This suggests that the less severely amnesic patients were able to use their residual explicit memory abilities to remember the pairings of studied items, and that this explicit memory for the pairings formed a basis for responding at test. It follows that in the cued word-stem completion task, control subjects may be using their unimpaired explicit memory as a basis for responding at test. Although subjects are instructed to complete the stems with the first word that comes to mind, it may be less effortful to use the cued stem as a retrieval cue for items on the trained list than it is to complete the stem by any other means. Support for this view comes from the finding that only subjects who are aware of the relationship between test items and trained items show novel associative priming (Bowers & Schacter, 1990). It must be remembered, however, that this view is not easily reconciled with the reports of dissociations between repetition priming and recall of novel associations due to changes in modality and to interference effects.

One might expect evidence from other types of task to be more informative. Moscovitch, Winocur and McLachlan (1986) found greater facilitation in the re-reading speed of pairs of unrelated words when the pairings of items were kept intact between training and test, as compared to when recombined. Musen and Squire (1990) were unable to replicate this result. McKoon and Ratcliff (1979) found greatest facilitation of lexical decision time when a target word was preceded by a trial in which its partner word from training was presented. As both trials required a lexical decision response, however, there were relatively long stimulus onset asynchronies (750-800 msec) which may have allowed subjects to strategically recall the target item to occur next trial, based on their explicit memory for the trained pairings. A study employing shorter stimulus onset asynchronies (150 msec; Neely & Durgunoglu, 1985), in which such strategic explicit recall is less likely to occur, found no attenuation of priming following the recombining of stimulus pairs between training and test. In this experiment, different tasks were performed in the training phase and the test phase, and the two items comprising a pair were not presented together. Carrol and Kirsner (1982) presented two words simultaneously and had subjects perform the same task (responding to indicate whether both words were real or not) in both phases of the experiment. Under these conditions, when stimulus pairs are repeated intact they exactly reinstate the processing demands of the training phase trial with that pair, and so evidence for episodic retrieval underlying the priming effect is most likely to be elicited. Carroll and Kirsner (1982) in fact found just as much priming of recombined word pairs as pairs kept intact; there was no evidence of any contribution of the novel associations between items to the priming effects observed. These results are consistent with an item-specific representation account, where it is the activation of representations dedicated to individual items for the purposes of stimulus recognition that results in repetition priming.

Dagenbach, Horst and Carr (1990) were able to find evidence for the priming of novel associations in a lexical decision task, with 200 msec SOAs between the prime and the target item, but only after extensive study of the stimulus pairings and only when one of the items in the pair was unfamiliar to subjects. The effect was observed (Experiment 3) when the training phase, extending over five weeks, consisted of subjects writing 24 sentences three times per week, each sentence meaningfully relating the words in a stimulus pair; for four of the weeks' training, subjects studied the stimuli again and were given ten cued-recall tests, with corrections, for the pairings. When both of the words in a stimulus pair were familiar to subjects, the priming of novel associations was not observed under these conditions (Experiment 4). Nor was the effect observed after 15 minutes study of the 24 word pairs and ten cued recall tests, even though this study led to 99.8% recall accuracy (Experiment 1). Dagenbach *et al.* (1990) argued that after extensive study, the items in a stimulus pair come to be represented together in semantic memory. Such extensive study is not necessary for the representation of items together in the kind of memory that underlies performance on direct tests of recognition and recall.

ORGANISATION OF THIS THESIS

This thesis begins with an experiment that examined the effects of recombining stimulus pairings, between training and test, upon repetition priming. As outlined above, episodic accounts and item-specific representation accounts of repetition priming make different predictions about the extent to which the processing of recombined pairs, as compared to intact pairs, should be facilitated. Experiment 1 therefore addresses the distinction drawn between these two classes of theoretical account. The particular task used in Experiment 1, speeded same/different matching of simultaneously presented picture-word pairs, was designed to reduce the likelihood that subjects employed explicit memory as a basis for responding. Experiments 2 and 3 provided further support for the locus of the priming effect identified in Experiment 1. Experiment 4 was conducted to examine whether information about the pairings of stimuli was encoded in the representations underlying recognition memory.

The locus of repetition priming identified is further refined by the experiments contained in Chapter 3. Experiment 5 examined the domain-specificity of the effect. Experiment 6 examined whether the confounding of item-specificity with domain-specificity could account for the results of the earlier experiments, by using pairs of stimuli all drawn from within the single domain of object pictures.

Chapter 4 contains two experiments. The first (Experiment 7) examined whether priming effects observed in the speeded same/different matching task were independent of the particular decision and response ("same" or "different") associated with each stimulus item. The second (Experiment 8) attempted to resolve whether the results of Experiment 7 were influenced by subjects' use of explicit memory as a basis for responding, rather than reflecting automatic priming. This was done by examining the effects of changing the proportion of items repeated from training at test.

Chapter 5 contains a single experiment (Experiment 9) which examined the effects of changing the interpretation demanded of homographs, between training and test, upon repetition priming in the speeded same/different matching task. Again, different predictions about the outcome of this experiment are made by episodic and item-specific representation accounts of the effect.

The effect of recombining the pairings of novel objects upon repetition priming was examined, in Chapter 6, by Experiment 10. This experiment allowed an important further refinement to be made to the description of the locus of repetition priming identified in earlier experiments, namely the role of pre-existing representations in producing the effects observed.

The final experiment of this thesis, Experiment 11, is contained in Chapter 7. This experiment examined the necessity of the identification of stimuli in producing repetition priming, and the effects of changing the task performed, within this constraint, upon priming effects observed.

Discussion of the results of these eleven experiments is presented in Chapter 8. A locus of the repetition priming effect is described, and implications for the *generality* of episodic accounts and existing item-specific representation accounts of the effect are considered.

2

AN ITEM-SPECIFIC LOCUS OF REPETITION PRIMING

INTRODUCTION

The literature review in the previous chapter revealed that both item-specific representation accounts and episodic accounts of repetition priming can accommodate many of the effect's basic properties. These include dissociations between the priming effect and performance on tests of recognition and recall, the effect's modality- and domain-specificity and its sensitivity to variations in surface form. In this chapter, a series of experiments is described concerning a set of circumstances in which the two classes of account make different predictions. The experiments involve manipulation of the context in which individual items occur between training and test, that is, the integrity of specific pairings of simultaneously presented stimuli.

According to an account based on the retrieval of prior processing episodes, if a task requires that two items are processed together then they will be represented together in the episodic record of that processing event. Reinstating the exact same processing demands - repeating the same two items and the same task to be performed - in a subsequent test phase of the experiment will produce the best retrieval cue for that particular episode and thus produce the largest priming effect. Any change in processing demands between the earlier, training encounter and the test encounter with a stimulus will attenuate the priming effect. In a task in which stimuli comprise two simultaneously presented items, therefore, showing a pair of items at test that both had been seen during training, but not paired with each other, should produce less repetition priming than repeating a pair of items that had been paired at training. This manipulation can be regarded as affecting the context in which each item occurs (its particular partner) which Jacoby (1983b) argues forms an integral part of the memory representation underlying repetition priming.

A different pattern of results is predicted by an item-specific representation account. The representations underlying repetition priming are deemed to contain only information pertinent to the recognition of *individual* stimulus items. Two items processed together will utilise two independent representations, so repeating any two previously trained items should produce just as much priming as repeating a pair of items that were trained together.

The item-specific representation and episodic retrieval accounts therefore differ in whether they deem novel associations between stimuli to be encoded in the representations that underlie repetition priming.

Experiment 1

The first experiment to be reported in this thesis used the logic of recombining or keeping intact the pairings of stimuli, as outlined above, to investigate the nature of the memory representations underlying the repetition priming effect. As described in Chapter 1, there is evidence that subjects use explicit memory as a basis for responding in some repetition priming tasks (most notably cued word-stem completion), and this has made interpretation of the results of those experiments very difficult. In this first experiment, therefore, the task was designed to be one in which the likelihood that explicit memory was used by subjects as a basis for responding was minimised. This aim was approached in a number of ways. Firstly, the items comprising each stimulus pair were presented simultaneously. There was therefore no inter-stimulus temporal gap during which subjects could generate expectancies about the occurrence of the second item on the basis of recognition of the first. Secondly, the task was speeded and stimuli were all highly familiar to subjects. It is assumed that explicit memory processes are more time consuming than the processes of stimulus identification necessary for performance of this task; subjects were therefore less likely to employ explicit memory processes as a basis for responding given the speeded nature of the task. Thirdly, the training phase of the experiment, in which stimuli were first presented, and the test phase, in which a subset of those items were repeated, ran consecutively. There was therefore no obvious study-test distinction in the experiment. Subjects were not informed of the distinction between the two phases, and they performed the same task in each.

In Experiment 1, subjects were required make same/different decisions accurately, but as quickly as possible, to pairs of stimuli comprising an object picture and a written object name. The task consisted of two phases, a training phase in which pairs were initially presented and a test phase in which a subset of pairs from the training phase were repeated. Repetition priming was measured by faster response times to repeated pairs in the test phase, as compared to a matched set seen for the first time at test. Of the repeated stimuli, the pairings of some items were preserved between training and test, while the pairings of others were recombined to give new stimulus pairs. In these latter stimuli, both the picture and word had been seen at training, but not with each other.

The different predictions of an episodic and an item-specific representation account of repetition priming are best illustrated with an example. Suppose that trained stimuli include the *picture*-NAME pairs: *grapes*-CHAIN, *snowman*-FISH and *screwdriver*-CHURCH, all of which would receive a "different" response. According to an episodic retrieval account, repeating *grapes*-CHAIN in the test phase would exactly reinstate the processing demands of the training episode and would produce maximal benefit in response time at test. Presenting the pair *snowman*-CHURCH at test, where both items have been seen before, but not along with each other, would produce less repetition priming. The exact processing demands of an earlier episode would not be reinstated; the recombined pair would therefore act as a less efficient retrieval cue than a pair repeated intact. According to the item-specific representation account, however, there would be no such effect of recombining pairings of items between study and test encounters. The training encounters with the pairs of items *grapes*-CHAIN, *snowman*-FISH and *screwdriver*-CHURCH would result in a representation of each individual item being activated, or formed. Upon repetition in the test phase, an intact pair such as *grapes*-CHAIN and a recombined pair such as *snowman*-CHURCH both contain two items that have had their individual, item-specific representations activated. This class of account predicts that there would be as much facilitation of responding to each. The focus of interest in Experiment 1 was therefore in the degree to which recombining the pairings of items attenuated the repetition priming effect.

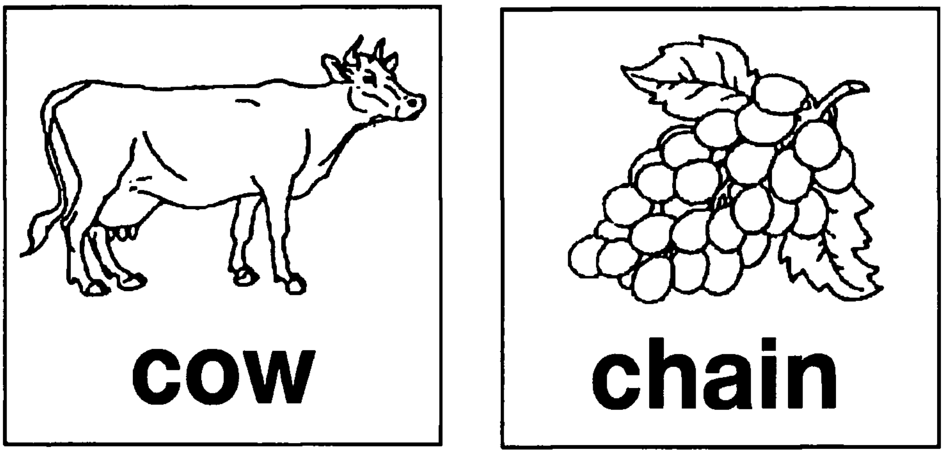
METHOD

Subjects. There were 16 subjects, all undergraduate or postgraduate students with normal or corrected-to-normal vision.

Materials. One hundred items were taken from the stimulus materials produced by Snodgrass and Vanderwart (1980). These items comprise line drawings of familiar objects and their written names. They were divided into 10 sets, each containing 10 items. The sets were matched for measures of name agreement, image agreement, familiarity, complexity and object name frequency. The means and standard deviations of each of these ratings for each of the 10 sets of stimuli are given in Appendix 1.

These materials were organised to produce pairs consisting of a line drawing of an object (Snodgrass & Vanderwart, 1980, Appendix A) and an object name. There were two sets of 10 *same* pairs containing the line drawing of an object along with its correct name. Four sets of 10 *different* pairs contained the line drawing of an object along with an unrelated name. An example of each type of pair is given in Figure 2.1. A set of filler pairs (32 same pairs and 12 different pairs) was developed from remaining Snodgrass and Vanderwart items. American forms of object names (garbage can, clothespin) were anglicised (dustbin, clothespeg).

Figure 2.1. *Examples of Same (left) and Different (right) Picture-Name Pairs Used in Experiment 1.*



Design and Procedure. The experiment consisted of two phases, a training phase and a test phase. These ran consecutively and subjects performed the same task in each. They were not told of the distinction between the two phases.

Each subject was tested individually, viewing an AppleColor High-Resolution RGB Monitor at a distance of approximately 50 cm. Stimuli were presented, and responses recorded, using a Macintosh computer and SuperLab 1.5.9 software (these details are common to all of the experiments reported in this thesis). Stimulus pairs comprising a line drawing of an object (scaled to subtend a visual angle of 6.3° vertically; mean 6.9°, range

2.3-10.9° horizontally) and an object name (lower case, bold helvetica font, subtending a visual angle of 1.7° vertically; mean 5.3°, range 3.4-9.7° horizontally) were presented on the monitor. The picture was presented together with, and directly above, the name (separated by a visual angle of 1.1°). Subjects were required to respond by pressing one of two keys on the computer keyboard to indicate whether the picture and the name referred to the same object or to different objects. All subjects responded with the right index finger on key "M" to indicate a "same" match and with the left index finger on key "Z" to indicate a "different" match. Following a response, the screen was cleared and the next picture-word pair presented after an interval of 1500 msec. Instructions stressed that responses should be made as quickly as possible, but not at the expense of accuracy.

Practice with 4 filler pairs preceded the training phase, in which one of the same sets and two of the different sets were presented, along with 20 same filler pairs and 10 different filler pairs, in a random order. There were thus an equal number of "same" and "different" responses required. The training phase lasted approximately three minutes.

The test phase carried on directly from the training phase, beginning with 4 practice trials. The same set and one of the different sets presented during training were re-presented in the test phase. These are referred to as the *primed same* items and the *primed different* items. A previously unseen same set and a previously unseen different set were also presented, referred to as *unprimed same* items and *unprimed different* items. The items in the remaining different set presented during training were recombined to give new pairings of an object picture and an unrelated name and were presented in the test phase. For these recombined pairs, both items within each had therefore been seen before, but not paired with each other. These are referred to as *recombined different* items.

Ten same filler pairs that were presented during the training phase were re-presented in the test phase, along with a further 10 same filler pairs and the final matched set of 10 different pairs used as filler items. Thus in the test phase, an equal number of "same" and "different" responses were required, and to items that were repeated from the training phase, an equal number of each response was required. The test phase lasted approximately three minutes.

All pairs were presented in a random order within each phase, with a different order used for each subject. The design of Experiment 1 is summarised in Table 2.1.

Table 2.1. *Summary Experimental Design for Experiment 1.*

Phase		
Training		Test
10 same pairs	→	10 primed same pairs
10 different pairs	→	10 primed different pairs
10 different pairs	→	10 recombined different pairs
		10 unprimed same pairs
		10 unprimed different pairs
Filler Pairs		
10 same pairs	→	10 same pairs
10 same pairs		10 same pairs
10 different pairs		10 different pairs

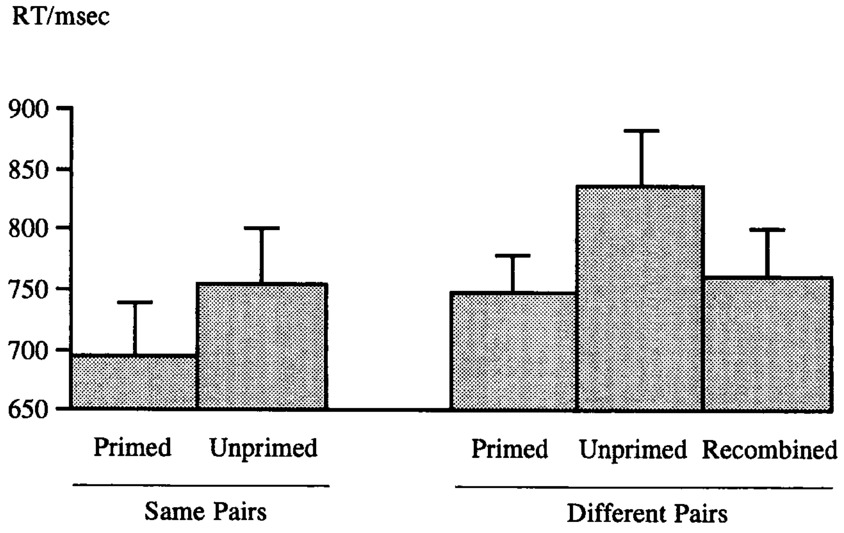
Same pairs contained an object picture along with its correct written name. Different pairs contained an object picture along with an unrelated written name. Primed pairs were repeated from the training phase of the experiment in the test phase. One set of 10 same filler pairs were also repeated from the training phase in the test phase.

Materials were rotated between sets across subjects. Same pairs were rotated between the primed and unprimed sets, thus eight subjects responded to each item in each of these conditions. Different pairs were rotated between the primed, unprimed and the to-be-recombined (training phase) sets and a set of ten different fillers pairs, thus four subjects responded to each item in each condition.

RESULTS

The measure of interest in Experiment 1 was the latency of correct responses made to different types of picture-name pairs in the test phase. Figure 2.2 shows the mean correct response latency in milliseconds to each item type. Appendix 2 includes the standard deviaions associated with these means, the percentage of response latencies over 2000 msec and the mean percent error rate to each item type. Latencies over 2000 msec (1.00% of responses) and latencies of incorrect responses (1.26% of remaining responses) were excluded from the mean response latencies.

Figure 2.2. *Experiment 1. Mean Test Phase Correct Response Latencies (in Milliseconds).* Bars indicate the standard errors of the means.



Analysis of the arc-sine transformed proportions of response latencies over 2000 msec revealed no significant difference between the primed same pairs and the unprimed same pairs ($p>.1$), or between the three types of different pair ($p>.1$). There was no significant difference in the arc-sine transformed error rates for primed same pairs and unprimed same pairs ($p>.1$), and no significant differences in the arc-sine transformed rates of errors made to the three types of different pair ($p>.1$).

The reaction time advantage in making "same" judgements relative to "different" judgements is a common finding (e.g. Krueger, 1983); separate analyses were carried out on the response latencies to same pairs and to different pairs.

One factor within-subjects analyses of variance (denoted by the subscript $_1$) were carried out on response latencies to same pairs and to different pairs. Analyses by items (denoted by the subscript $_2$) were also performed: within-items analyses on response latencies to same pairs, and between-items analyses on response latencies to different pairs. For same pairs, there was a significant effect of priming the items, $F_1(1,15)=8.39$, $p<.05$; $F_2(1,19)=6.10$, $p<.05$, with primed same pairs being responded to more quickly than unprimed same pairs. For different pairs, there was a significant effect of item type, $F_1(2,30)=8.34$, $p<.01$; $F_2(2,117)=3.19$, $p<.05$. Differences between individual means were examined using post hoc Newman-Keuls tests. There was a significant repetition priming effect, with primed different pairs being responded to significantly faster than the unprimed different pairs ($p_1<.01$; $p_2<.05$). The principal focus of interest in Experiment 1 concerns the recombined different pairs. These were responded to faster than the unprimed different pairs ($p_1<.01$; $p_2<.05$), and there was no effect of recombining the items within a pair; response latencies to the recombined different and primed different pairs did not differ significantly ($p_1>.1$; $p_2>.1$).

DISCUSSION

In Experiment 1 there was significant priming of responses made in the test phase to object picture-name pairs that were repeated from the training phase. This beneficial effect of repetition occurred both for same pairs, where the picture and the name referred to the same real object, and for different pairs, in which the picture and the word referred to different real objects. The priming effect was evident in both analyses by-subjects and by-items. Of particular interest is the finding that recombining items within different pairs to give new pairings at test (both members of which had been seen at training, but not with each other) appeared to have no effect upon the degree to which repeated items were primed. There was no reliable difference in facilitation of responding to recombined different as to primed different pairs.

These results are consistent with the item-specific representation accounts of repetition priming as outlined in Chapter 1, and suggest a negligible role, if any, for the retrieval of prior processing episodes. In an item-specific account, the picture and word within a different pair seen during Experiment 1 would be expected to be primed independently: they have separate perceptual identities and therefore separate pre-semantic representations dedicated to these identities for the purposes of recognition. This is as found. A picture or a word appears to be primed regardless of which other item accompanies it. An account based on episodic retrieval would not predict the observed pattern of results. The repetition of a primed different pair should act as a perfect retrieval cue for the training phase encounter with that pair; processing demands are exactly reinstated at test. With the recombined different pairs, both items have been studied, but not with each other, and although the same response is made, it is not made on the basis of consideration of the relations between the same two items. Episodic retrieval accounts would therefore predict less priming to the recombined different pairs than to the primed different pairs repeated verbatim.

Support for the item-specific representation accounts here depends upon a null result, namely the lack of a significant difference between response latencies to primed different pairs and recombined different pairs. Some caution must therefore be exercised in drawing strong conclusions from this finding. It is important to note, however, that while there was a very small and unreliable advantage in responding to the primed different pairs over the recombined different pairs, there was substantial and significant facilitation in responding to both of these types of stimuli as compared to the unprimed pairs. Activation of pre-semantic item-specific representations provides the best account of these priming effects, while any contribution from the retrieval of prior processing episodes is negligible.

It remains the case, however, that the observed repetition priming might not show sensitivity to the pairings of items simply because this novel association is not adequately encoded, given the study conditions in Experiment 1. Indeed, Graf and Schacter (1985, 1989; Schacter & Graf, 1986) found an effect of novel associations in priming of cued word-stem completion only following elaborative study tasks, i.e. those which require subjects to relate studied pairs of words in a meaningful manner. Such encoding is said to result in a "unitized" representation of both studied items, such that the whole will be reactivated from only partial cues. Experiment 2 therefore examined whether repetition priming of same/different decisions to picture-name pairs would show sensitivity to the novel pairings following a more elaborative study task.

Experiment 2

In Experiment 2 different tasks were performed in the training and the test phases of the experiment. In the training phase, subjects made same/different decisions to picture-name pairs on the basis of category membership, where categories were defined as: man-made objects found indoors, man-made objects only ever found outdoors, natural objects that might be found indoors, and natural objects only ever found outdoors. This task required consideration of the equivalence of the two items based on a semantic property rather than mere equivalence of identity. In the test phase of the experiment, subjects made same/different decisions on the basis of identity, as in Experiment 1.

METHOD

Subjects. There were 16 subjects, all undergraduate or postgraduate students with normal or corrected-to-normal vision.

Materials. One hundred items taken from Snodgrass and Vanderwart (1980) were divided into 10 sets of 10 items, as in Experiment 1. These materials were organised to produce pairs consisting of a line drawing of an object (Snodgrass & Vanderwart, 1980, Appendix A) and an object name. Two sets of 10 *same* pairs contained the line drawing of an object along with its correct name. Four sets of 10 *different* pairs contained the line drawing of an object along with an unrelated object name. These unrelated objects were also members of different *categories*, where the categories in question were: man-made objects found indoors, man-made objects only ever found outdoors, natural objects that might be found indoors and natural objects only ever found outdoors. The four categories were each represented 10 times in the 40 different pairs described above. A set of filler pairs (22 same pairs and 42 different pairs) was developed from remaining Snodgrass and Vanderwart items. Here, 26 of the different pairs had object pictures and object names belonging to the same category and 16 had pictures and words belonging to different categories.

Design and Procedure. The experiment consisted of two phases, a training phase and a test phase. The two phases were separated only by explanation of the test phase instructions to subjects, which lasted approximately two minutes. In the training phase, subjects were required to base their responses to stimulus pairs on whether the two items within the pair belonged to the same semantic category, as defined above, or to different categories. In the test phase, subjects were required to base their responses on whether the picture and word comprising a pair had the same identity or had different identities, as in Experiment 1.

Stimuli were presented as in Experiment 1. Again, subjects responded with the right index finger on key "M" to indicate a "same" match and with the left index finger on key "Z" to indicate a "different" match.

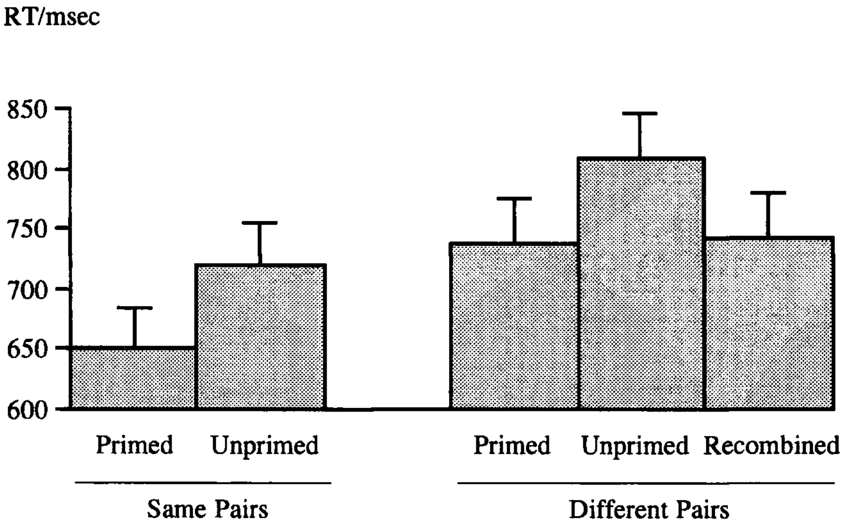
Practice with 4 filler pairs preceded the training phase. In the training phase one of the same sets and two of the different sets were presented. There were also twenty different filler pairs which contained two items with different identities, but which were members of the same category. There were also 10 different filler pairs containing two items with different identities which were members of different categories. There were thus an equal number of "same" and "different" responses required. The training phase lasted approximately four minutes. Stimulus pairs were presented in a random order.

The test phase was as that of Experiment 1. Materials were rotated between sets across subjects, as in Experiment 1.

RESULTS

The measure of interest in Experiment 2 was the latency of correct responses made to picture-name pairs in each condition of the test phase. Figure 2.3 shows the mean correct response latency in milliseconds to each item type. Appendix 3 includes the standard deviations associated with these means, the percentage of response latencies over 2000 msec and the mean percent error rate to each item type. Latencies over 2000 msec (0.63% of responses) and latencies of incorrect responses (3.14% of remaining responses) were excluded from the mean response latencies.

Figure 2.3. *Experiment 2. Mean Test Phase Correct Response Latencies (in Milliseconds).* Bars indicate the standard errors of the means.



Analysis of the arc-sine transformed proportions of response latencies over 2000 msec revealed no significant difference between the primed same pairs and the unprimed same pairs (p>.1), or between the three types of different pair (p>.1). There was no significant difference in the arc-sine transformed error rates for primed same pairs and unprimed same pairs (p>.1), and no significant differences in the arc-sine transformed rates of errors made to the three types of different pair (p>.1). One subject was replaced in these analyses, having made 18% of responses with latencies over 2000 msec and making 12.2% errors on the remaining items. (The mean percentage of responses with latencies over 2000 msec, including this subject's replacement, was 0.63%, with a standard deviation of 2.0. The mean error rate, including this subject's replacement, was 3.14%, with a standard deviation of 2.1. The responses of the excluded subject were therefore atypical.)

Separate one factor within-subjects analyses of variance (denoted by the subscript $_1$) were carried out on response latencies to same pairs and to different pairs. Analyses by items (denoted by the subscript $_2$) were also performed: within-items analyses on response latencies to same pairs, and between-items analyses on response latencies to different pairs. For same pairs, there was a significant effect of priming the items, $F_1(1,15)=11.97$, $p<.01$; $F_2(1,19)=7.494$, $p<.05$, primed same pairs being responded to faster than unprimed same pairs. For different pairs, there was a significant effect of item type, $F_1(2,30)=8.55$, $p<.01$; $F_2(2,117)=3.266$, $p<.05$. Differences between individual means were examined using post hoc Newman-Keuls tests. In the analysis by subjects, there was a repetition priming effect, i.e. primed different pairs were responded to significantly more quickly than the unprimed different pairs ($p_1<.01$). In the analysis by items, this difference did not reach statistical significance. The recombined different pairs were responded to more quickly than the unprimed different pairs ($p_1<.01$; $p_2<.05$). There was no effect of recombining the items within a pair; response latencies to the recombined different and primed different pairs did not differ significantly ($p_1>.1$, $p_2>.1$).

DISCUSSION

The results of Experiment 2 both confirm and extend those of Experiment 1. The pattern of statistically significant results observed in the two experiments differed in only one regard. While the primed different pairs were responded to more quickly than the unprimed different pairs in Experiment 2, this difference was statistically significant only in the analysis by subjects. In the analysis by items, this difference approached statistical significance (the critical difference required for $p<.05$ on the Newman-Keuls test being 64.19 msec, the observed difference being 64.12 msec).

Again, there was no significant difference in the amount of priming between pairs kept intact and pairs recombined between training and test. This occurred despite subjects having performed a training phase task that was deemed to require consideration of some meaningful relation between the two items in a pair, a manipulation expected to increase any role the novel association between the two items might have in the repetition effect. Subjects reported that they found the training phase task difficult, and took considerably longer to perform it (mean training phase response latency being 1963 msec in Experiment 2, as compared to 826 msec in Experiment 1); yet these training differences were not reflected in the pattern of test phase results. This finding was confirmed by an analysis of variance performed with experiment (1 or 2) as a between-subjects factor, and response latencies to the five types of test phase item (as represented in Appendices 2 and 3) as levels of a within-subjects factor. There was no main effect of experiment [$F(1,30)<1$] and no interaction between experiment and test item type [$F(4,120)<1$]. Thus, changing the training phase task between Experiments 1 and 2 affected neither the status of the recombined different pairs, nor the latencies of responses made to test phase items.

The results of Experiment 2, like those of Experiment 1, are consistent with an item-specific representation accounts of the observed repetition priming effect. The facilitation in responding to a pair of repeated items was not sensitive to whether the exact studied pairings were reinstated at test, suggesting that the effect does not depend upon memory for entire perceptual events.

A change in the *magnitude* of the priming effects observed would also be predicted by an account based on episodic retrieval, as in Experiment 2 different tasks were performed in the training and the test phases. Since the exact processing demands of the training phase were not reinstated at test, an episodic retrieval account would regard a test phase item in Experiment 2 as a less efficient retrieval cue for the training episode than in Experiment 1, where training and test tasks were identical. In fact, contrary to this prediction of the episodic retrieval hypothesis, no difference between the two experiments in the magnitude of the priming effects was observed. This finding is again consistent with pre-semantic, item-specific representations being the locus of the repetition effect. The training phases in Experiments 1 and 2 both required identification of items and hence would both result in activation of each item's specific, independent representation, despite differing in the task that was subsequently performed. According to the item-specific representation accounts, repetition priming results from reactivation of these representations at test. The two experiments had identical test phase tasks, and hence did not differ in the magnitude of the priming effects observed.

Experiments 1 and 2, as described above, did not allow for a within-items analysis of the response latencies made to different pairs. Different pairs were rotated between the two sets presented in the training phase and the third matched set presented at test. The consequent recombination of one trained set between that phase and the test phase meant that pairs were not seen each as primed different, unprimed different and recombined different (but rather as primed different, unprimed different, and to-be-recombined different). Experiment 3 was therefore performed to address this issue. It served to replicate the findings of Experiment 1, and to allow for a within-items analysis.

Experiment 3

METHOD

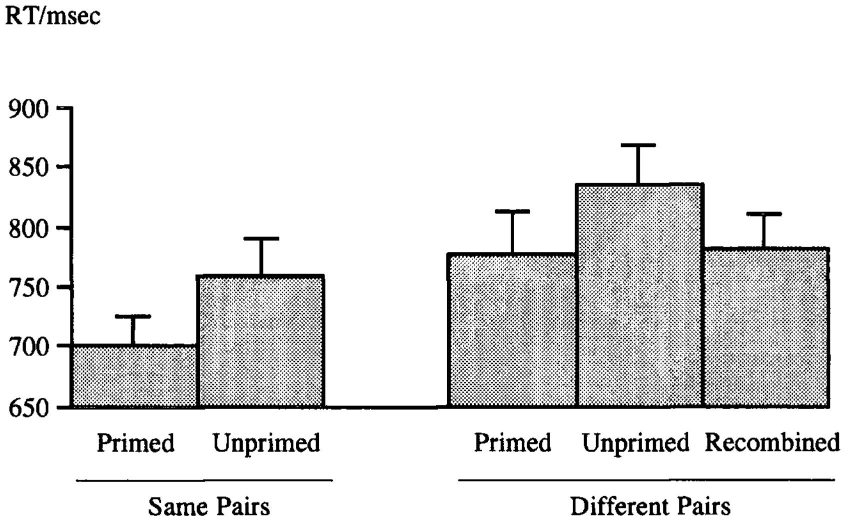
Experiment 3 differed from Experiment 1 in only two respects. Different pairs were rotated between the primed different, unprimed different and recombined different sets, and a set of 10 different filler items, across subjects. Thus, in Experiment 3, each different pair was seen by four subjects in each of the test phase sets. Rotation of the stimuli in this way allowed analyses both within-items and within-subjects.

In Experiment 3, subjects were 16 members of the Medical Research Council Applied Psychology Unit subject panel, mean age 31.3 years, range 20-39. All had normal or corrected-to-normal vision.

RESULTS

The measure of interest in Experiment 3 was the latency of correct responses made to different types of picture-name pairs in the test phase. Figure 2.4 shows the mean correct response latency in milliseconds to each item type. Appendix 4 includes the standard deviations associated with these means, the percentage of response latencies over 2000 msec and the mean percent error rate to each item type. Latencies over 2000 msec (1.00% of responses) and latencies of incorrect responses (3.03% of remaining responses) were excluded from the mean response latencies. Analysis of the arc-sine transformed proportions of response latencies over 2000 msec revealed no significant difference between the primed same pairs and the unprimed same pairs ($p>.1$), and no significant differences between the three types of different pair ($p>.1$). There was no significant difference in the arc-sine transformed error rates for primed same pairs and unprimed same pairs ($p>.1$), and no significant differences in the arc-sine transformed error rates between the three types of different pair ($p > .1$).

Figure 2.4. *Experiment 3. Mean Test Phase Correct Response Latencies (in Milliseconds).* Bars indicate the standard errors of the means.



Separate one factor within-subjects (F_1) and within-items (F_2) analyses of variance were carried out on the response latencies to same pairs and to different pairs. For same pairs, there was a significant effect of priming the items, $F_1(1,15)=15.01$, $p<.01$; $F_2(1,19)=6.11$, $p<.05$, with primed same items being responded to more quickly than unprimed same items. For different pairs, there was a significant effect of item type, $F_1(2,30)=6.93$, $p<.01$; $F_2(2,78)=3.91$, $p<.05$. Differences between individual means were examined using post hoc Newman-Keuls tests. There was a repetition priming effect, with primed different pairs responded to significantly more quickly than the unprimed different pairs ($p_1<.01$; $p_2<.05$). The recombined different pairs were also responded to faster than the unprimed different pairs ($p_1<.01$; $p_2<.05$). There was no significant effect of recombining the items within a pair ($p_1>.1$; $p_2>.1$).

DISCUSSION

In Experiment 3, as in Experiments 1 and 2, there was repetition priming of both same and different pairs, as evidenced by faster test phase responses to pairs seen in the training phase. As in Experiments 1 and 2, there was no significant difference between latencies of responses made to object picture-name pairs recombined between training and test and pairs which were kept intact: both sets of items were primed. These findings were evident in both analyses by subjects and by items, and lend further support to the conclusion that independent, item-specific representations underlie repetition priming of the two simultaneously presented stimuli, with a negligible role, if any, for the retrieval of prior processing episodes.

The lack of sensitivity of the priming measure to the pairings of items in Experiments 1, 2 and 3 begs a question, namely whether subjects were able to remember the pairings of items at all. If subjects were able to remember the pairings of items and had been using this episodic memory of the training encounters with stimulus pairs as a basis for responding to them in the test phase, a different pattern of results to that observed would be predicted. The priming effect would be expected to show sensitivity to the novel association between items in a pair. That there was no such sensitivity to the novel associations in Experiments 1, 2 and 3 therefore suggests that subjects do not explicitly refer back to their performance on the training task. The absence of an effect of the change in training task between Experiments 1 and 2 also suggests that explicitly remembering the training pairings played no role in test phase performance. The categorisation task used in Experiment 2 would be expected to produce greater levels of explicit memory for the studied pairs than the identity matching task used in Experiment 1 (Craik & Lockhart, 1972). Thus any role of explicit memory in test phase performance would be expected to be enhanced in Experiment 2. The two experiments in fact differed neither in the pattern of results nor the magnitude of the priming effects.

The results of Experiments 1, 2 and 3 therefore suggest that explicit remembering of the training phase encounters played no role in test phase performance. However, a simple floor effect in explicit memory must be ruled out as an explanation of the observed pattern of results, if it is to be argued that the representations underlying the priming effect observed do not represent such novel associative information.

Experiment 4 therefore examined whether subjects showed explicit memory for the pairings of items under the same training conditions as Experiment 2. If subjects do show above-chance recognition memory for the pairings of items, then the lack of sensitivity of the priming measure to this information seen in Experiment 2 cannot be due to subjects being unable to remember this information. Such a finding would be consistent with the memory representations underlying the repetition effect being independent and item-specific, and not representing entire perceptual episodes.

Experiment 4

The instructions to subjects and training phase of Experiment 4 were identical to those of Experiment 2. The test phase, however, comprised a surprise forced-choice recognition memory test between picture-word pairs that (a) had been presented with each other, or (b) had both been seen in the training phase but not paired with each other. Accurate recognition of the former, with the latter as distractor items, would therefore reveal memory for the novel association between items in a pair under the encoding conditions that did not produce any effect of this association on a priming task.

METHOD

Subjects. There were 16 subjects, all undergraduate or postgraduate students with normal or corrected-to-normal vision.

Materials. Materials were as for Experiment 2.

Design and Procedure. The experiment consisted of two phases, a training phase and a recognition test phase. The two were separated by the recognition test instructions.

The training phase was identical to that of Experiment 2, with subjects being required to match items in an object picture-name pair on the basis of same or different category membership.

The training phase was followed by a surprise forced-choice recognition memory test; subjects were given no indication of its occurrence in the instructions provided before the experiment began. The recognition test instructions, separating the two phases of the experiment, lasted approximately two minutes. There were 10 recognition test trials in which two object picture-name pairs were presented on the screen at the same time. In each trial, one pair came from one of the different sets presented during the training phase. The other pair contained items from the remaining different set presented during training, recombined to give new pairings of picture and name. In these recombined pairs both picture and name had therefore been seen before, but not paired with each other. The two pairs presented in a recognition test phase trial therefore differed only in whether the items within each had been seen together, or seen with other partners, during training. On each recognition test trial, one pair was thus equivalent to a primed different pair from the test phase of Experiment 2, and the other equivalent to a recombined different pair.

In the test phase, the object pictures were scaled to subtend a visual angle of 4.0° vertically and mean 4.4°, range 1.5-6.9°, horizontally; object names subtended 1.1° vertically and mean 3.4°, range 2.2-6.2°, horizontally. Object pictures and names within a pair were separated by a gap of 1.1°, the picture being presented above the word, and the two pairs in a trial were separated by 2.2°, being presented side-by-side. In five of the ten trials the primed different equivalent pair was presented on the left and the recombined different equivalent pair on the right, and in five of the trials vice versa. Trials were presented in a random order. Subjects responded by pressing one of two alternative keys on the computer keyboard to indicate which of the two pairs they had seen during the training phase ("Z" for left hand side pair and "M" for right hand side pair). Instructions stressed that the recognition test was one for pairings seen during training and not individual items. Subjects were required to guess when not confident in making a correct response. Materials were rotated between sets across subjects.

The dependent measure was the number of correct recognition responses made during the test phase.

RESULTS

The mean number of correct recognition responses made in the test phase was 7.94 (sd=0.97) out of a possible maximum of 10. A single sample t-test was performed on the difference between the proportion correct and chance levels of performance, both by-subjects (t_1=11.775, df=15, p<.0001) and by-items (t_2=9.485, df=9, p<.0001). The recognition rate observed was well above-chance.

DISCUSSION

Experiment 4 revealed that subjects had above-chance recognition memory for the novel associations between items in picture-word pairs following the encoding conditions that pertained in Experiment 2. In that experiment there was no evidence of performance on the priming task (same/different matching) showing any sensitivity to the pairings of items. However, in Experiment 2 there were more test phase trials than in Experiment 4. It is conceivable that explicitly remembering the pairings of items as a basis for responding is only possible at shorter lags, and hence has effects in Experiment 4 but not Experiment 2. A post hoc analysis was performed on the results of Experiment 2, to examine whether the pattern of response latencies observed in the test phase differed with respect to the lag between training and test phase encounters with stimuli. A two factor within-subjects analysis of variance was performed on the mean correct test phase response latencies with item type (primed different or recombined different) as one factor, and lag as the second. Test phase trials were ranked according to the number of trials intervening between the training presentation and the test phase presentation of each stimulus pair (for the recombined different pairs, there were two training phase trials contributing items to each test phase pair; the mean number of intervening trials was taken). The first five ranked test phase trials of each type of stimulus pair were defined as short lag, the subsequent five test phase trials of each type of stimulus pair were defined as long lag. There was no significant interaction between lag and item type ($F<1$). There was therefore no evidence that a difference in the lag between training and test encounters in Experiments 2 and 4 was responsible for the different sensitivities of the response measures in those two experiments to the pairings of stimulus items.

A number of conclusions can be drawn from the results of Experiment 4. Firstly, the lack of an effect of recombining items in a pair upon the priming seen in Experiment 2 cannot simply be due to subjects being unable to represent the association between items given the training conditions; the same training conditions gave rise to above-chance recognition memory for the pairings in Experiment 4. This finding is important therefore because it strengthens the conclusions that were drawn on the basis of the results of Experiments 1, 2 and 3; namely that the lack of an effect of recombining the pairings of items reflects the item-specificity of the memory representations underlying priming, rather than some artefact.

Secondly, the finding that subjects can remember the associations between items, while a priming task shows no sensitivity to these same associations, indicates that explicit memory played no role in performance on the priming task. The memory representations underlying the repetition priming effect observed in Experiment 2 therefore depend on item-specific information. They are not sensitive to novel associative information, unlike the representations underlying performance on the recognition memory test.

The results of Experiments 2 and 4 taken together, then, reveal a dissociation between the occurrence of a priming effect and performance on an explicit memory task. Interestingly, this dissociation is in the opposite direction to the more common finding that repetition priming can be preserved in the absence of recognition or recall for the same information, either due to the latter being at chance levels in normal subjects (e.g. Merikle & Reingold, 1991) or impaired due to neurological insult (see Schacter, 1987). In Experiment 4, subjects demonstrated explicit memory for a class of information (the novel pairings between items presented together) that did not contribute to the priming effects observed in Experiment 2.

GENERAL DISCUSSION

The series of experiments reported in this chapter examined the nature of the representations underlying repetition priming of pairs of stimuli presented simultaneously.

The main findings can be summarised as follows: There was no significant attenuation of the priming effect when the pairings of pictures and words presented together were changed between training and test phases of the experiment (Experiments 1 and 3). This was also the case when the training task required explicit consideration of some relationship based on semantic properties of the two items in each pair (Experiment 2). Subjects were able to remember the pairings of items at above-chance levels (Experiment 4), so it cannot simply be the case that they were unable to retain the associations between items given the training conditions.

In none of these experiments was there any reliable difference in the rates of errors made to the different item types. There was no suggestion that a speed-accuracy trade-off in subjects' responding could account for the observed latency data; such a pattern occurred in Experiment 2, but was not evident in Experiments 1 and 3.

The findings of no effect of recombining the pairings of items upon response latencies to repeated stimuli occurred in the context of significant differences between latencies to these stimuli and those made to unprimed stimuli, in each experiment. This pattern of results is best accounted for by an account of repetition priming which deems that a locus of the effect is in a perceptual representation system (Morton 1969, 1979; Tulving & Schacter, 1990). The memory representations in this system are dedicated to the structure and form of individual items for the purposes of identification. For now, no distinction is made between facilitated activation of perceptual representations and changes in the connections between such representations and semantic representations, as the item-specific locus of the repetition effect. I will return to this distinction in Chapters 5 and 6.

The findings of these four experiments present problems for theories of repetition priming that argue that the effect results only from retrieval of episodic records of entire processing events, or the reinstatement of prior processing demands (Jacoby, 1983a, 1983b; Roediger & Blaxton, 1987a, 1987b). This class of theory predicts that recombining pairs of stimuli, initially presented together, should attenuate the repetition priming effect; the recombined pair of items would act as a less efficient retrieval cue for the earlier processing episode, or reinstate less exactly the prior processing demands, than does the original pair of stimuli repeated together. No such differences were observed.

The priming task used in these experiments, speeded same/different matching, was intended to minimise the likelihood that subjects used explicitly remembered the pairings of items seen during training as a basis for responding at test. This rests on the assumption that explicit memory processes are more time consuming than the processes of stimulus identification and response selection necessary for performance in the same/different matching task; subjects are therefore less likely to employ explicit memory as a basis for responding, given the speeded nature of the task. The results obtained are consistent with this assumption. The priming task showed no sensitivity to the novel associations between items in Experiments 1, 2 and 3 even when the same encoding conditions did lead to above-chance recognition memory for the novel associations in Experiment 4. These results are therefore consistent with the suggestion made earlier, that the priming of novel associations, when observed in other tasks, may reflect subjects' use of explicit memory as a basis for responding. In a task such as cued word-stem competition, there are no time constraints to prevent subjects from strategically using the cued stem as a retrieval cue for target words that were presented at training. This conclusion is supported by the finding that only subjects who report being aware of the relationship between items presented at training and at test show novel associative priming effects on the cued stem-completion task (Bowers & Schacter, 1990), and the finding that when observed in amnesic patients, the effect tends to correlate negatively with the severity of the subjects' memory problems (Schacter & Graf, 1986; Shimamura & Squire, 1989).

Having established a locus of the repetition priming effect dependent upon representations of individual items, and not entire processing episodes, the nature of these representations is more closely examined in Chapter 3.

3

REFINING THE LOCUS OF REPETITION PRIMING

INTRODUCTION

While the results of Experiments 1, 2, 3 and 4 are consistent with item-specific representation accounts of the repetition priming effect, rather than retrieval of entire processing episodes, it has yet to be demonstrated that the memory representations involved are pre-semantic, with the locus of the priming effects being the stored perceptual representations involved in item recognition (Tulving & Schacter, 1990). The items used in Experiments 1, 2, 3 and 4 were *conceptually* as well as *perceptually* different. The pattern of results observed in those experiments would be predicted if priming relied upon some representation of the items' semantic properties rather than of their structure and form. These semantic representations could be shared by stimuli presented in all modalities (e.g. visual stimuli and auditory stimuli) and in all domains within a modality (e.g. read words and pictures). Experiments 1, 2, 3 and 4 do not distinguish between the activation of item-specific perceptual representations and item-specific conceptual representations as a locus of the priming effect. Chapter 3 contains two experiments, performed to further refine the conception of the representations underlying the priming effect described in the last chapter.

Experiment 5 examined the extent to which memory representations underlying priming in the same/different matching task are domain-specific. There is already evidence from a number of different paradigms suggesting that repetition priming effects in identification tasks are based on perceptual rather than conceptual representations. Morton (1979) found that having read words at training significantly reduced subsequent tachistoscopic identification thresholds for written words, while hearing words at training did not. Having heard words at training produced much larger priming effects in the proportion of words spoken against noise identified than did having read the words earlier. Similarly, within the visual domain, rather than between domains, Winnick and Daniel (1970) reported that tachistoscopic recognition of written object names was facilitated to a much greater extent by having named the written forms earlier rather than by naming the items in response to pictures or definitions. Morton (1979) found the naming of pictures at training reduced subsequent tachistoscopic identification thresholds for those pictures, while having named object words at training did not. Kroll and Potter (1984, Experiment 5) reported no priming between representational forms in a mixed word and picture reality decision task. Ellis *et al.* (1987) found that studying a picture of a person's face primed a subsequent familiarity decision to that face, while having studied the same person's written name did not.

Findings of modality-specificity and domain-specificity in repetition priming are compatible with both episodic accounts and item-specific representation accounts. In the case of the episodic class of theory, reduced or absent priming across representational forms is predicted because such a change entails a change in the processing demands associated with that stimulus item. The processing operations that lead to the identification of a visually presented word differ from those that lead to the identification of a visually presented picture. As repetition priming in an identification task results from the reinstatement of such data-driven processing, if the processing demands associated with an item change between training and test, there will be less facilitation in the latency and accuracy of responding to that item, as compared to circumstances when there is no change in processing demands. Roediger and Blaxton (1987b) presented such an argument in a discussion of specificity in priming.

According to item-specific representation accounts, findings of modality- and domain-specificity in repetition priming reflect the fact that different representations underlie the identification of stimuli from different modalities and domains. Visually presented object names, pictures of objects (or real objects) and heard object names have different perceptual forms, and hence there will be separate representations of the structure and form of each item necessary for its identification when presented in different modalities and domains. These separate representations are usually described as being organised into separate systems or subsystems. For example, on the basis of his findings, Morton (1979) described an auditory input system, a visual input system and a picture recognition system. Tulving and Schacter (1990; Schacter 1992b) describe similar subsystems of the perceptual representation system (PRS) that they argue underlies perceptual priming effects. The word form system is responsible for the recognition of visually presented words, while the functionally distinct structural description system is responsible for the recognition of visually presented objects. The conceptual information shared by stimuli presented in different modalities may be accessed only after perceptual representations have been activated, i.e. they are pre-semantic. Support for the organisation of perceptual representations into modality- and domain-specific systems comes from neuropsychological evidence. People may lose the ability to recognise stimuli presented in one particular modality or domain as a result of brain injury or disease, the ability to recognise those stimuli presented in different forms being spared. Ellis and Young (1988) reviewed such evidence.

Priming may not be entirely eliminated by a change in the modality or domain in which stimuli are presented. Both classes of theoretical account are able to accommodate this result, as was discussed in Chapter 1. The important point here is that when items presented at test share a conceptual identity with items presented during training, this is not sufficient to produce priming, or at least not maximal priming. It is necessary that they share perceptual forms.

That perceptual, and not conceptual, representations are the locus of the repetition priming effect observed on the picture-word same/different matching task used in Experiments 1, 2 and 3 of this thesis was further examined in Experiment 5. In this experiment, the surface forms of the items within a set of simultaneously presented picture-word pairs were reversed between training and test (i.e. from picture to word and from word to picture). Experiment 5 is therefore identical to Experiment 3 except that instead of the set of recombined different pairs, there is a set of *reversed-form* different pairs. The manipulation of representational form would be expected to attenuate the priming effect if it depends upon perceptual representations, but not if it depends upon conceptual, semantic representations.

Experiment 5

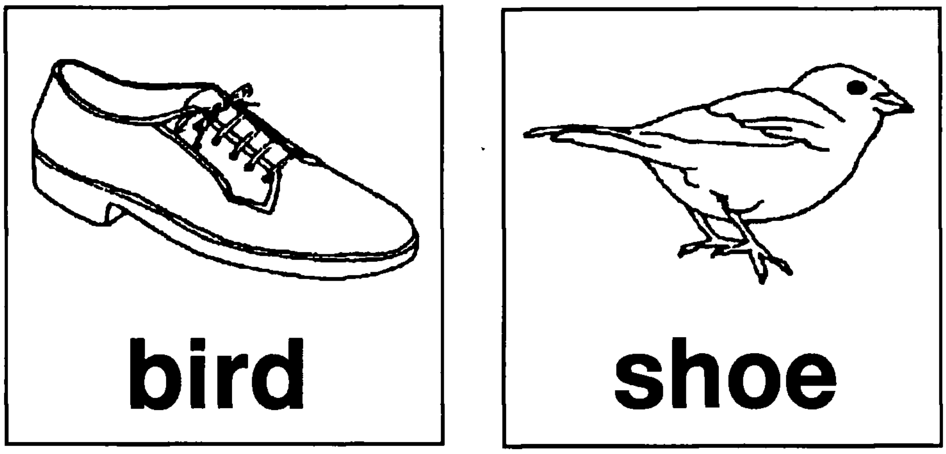
METHOD

Subjects. There were 16 subjects, all members of the MRC Applied Psychology Unit subject panel, mean age 28.13 years, range 18-38. All had normal or corrected-to-normal vision.

Materials. Materials were as for Experiment 3.

Design and Procedure. Experiment 5 was identical to Experiment 3 except with regard to one set of stimulus items. In Experiment 3, one set of ten different pairs presented at training had the pairings of items within it recombined when presented at test (the recombined different pairs). In Experiment 5, the picture-word pairs in this set presented during training were re-presented in the test phase with the representational form of the items within them swapped. Items that were originally seen by subjects as words were represented as pictures and items originally seen as pictures were re-presented as words. The pairing of items within this set was kept intact between the training phase and the test phase. This set of stimuli is referred to as the *reversed-form different* pairs. An example of a training phase different pair and its test phase reversed-form counterpart is given in Figure 3.1.

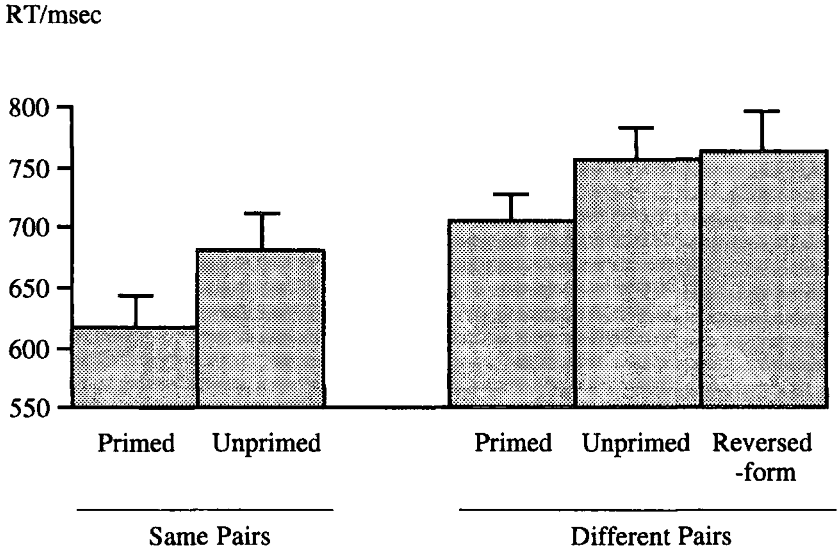
Figure 3.1. *Examples of a Different Pair (left) and its Reverse-Form Different Pair Counterpart (right) Used in Experiment 5.*



RESULTS

The measure of interest in Experiment 5 was the latency of correct responses made to the different types of picture-name pairs in the test phase. Figure 3.2 shows the mean correct response latency in milliseconds to each item type. Appendix 5 includes the standard deviations associated with these means, the percentage of response latencies over 2000 msec and the mean percent error rate to each item type. Latencies over 2000 msec (0.13% of responses) and latencies of incorrect responses (4.26% of remaining responses) were excluded from the mean response latencies. No response latencies made to same pairs were excluded due to being over 2000 msec. Analysis of the arc-sine transformed proportions of response latencies over 2000 msec revealed no significant difference between the three types of different pair (p>.1). There was no significant difference in the the arc-sine transformed error rates for primed same pairs and unprimed same pairs (p>.1), and no significant differences in the arc-sine transformed rates of errors made to the three types of different pair (p>.1). There was no apparent speed-accuracy trade-off in subjects' responding.

Figure 3.2. *Experiment 5. Mean Test Phase Correct Response Latencies (in Milliseconds).* Bars indicate the standard errors of the means.



Separate one factor within-subjects (F_1) and within-items (F_2) analyses of variance (ANOVAs) were carried out on the response latencies to same pairs and to different pairs. For same pairs, there was a significant effect of priming the items, $F_1(1,15)=11.67$, $p<.01$; $F_2(1,19)=12.79$, $p<.01$, primed same items being responded to more quickly than unprimed same items. For different pairs, there was a significant effect of item type, $F_1(2,30)=6.06$, $p<.01$; $F_2(2,78)=5.78$, $p<.01$. Differences between individual means were examined using post hoc Newman-Keuls tests. There was a repetition priming effect, i.e. primed different pairs were responded to significantly faster than the unprimed different pairs ($p_1<.01$; $p_2<.01$). The primed different pairs were also responded to significantly faster than the reversed-form different pairs ($p_1<.01$; $p_2<.01$). Latencies to the reversed-form different pairs and the unprimed different pairs did not significantly differ ($p_1>.1$; $p_2>.1$), i.e. there was no evidence of priming to pairs when the representational form (picture or word) of the items was changed between training and test.

DISCUSSION

Priming was evident in Experiment 5 following repetition of items in the same representational form as trained, but not following repetition of items with their representational form changed between training and test. Responding to the *picture*-WORD stimulus pair *shoe*-BIRD at training did not facilitate responding to the reversed-form pair *bird*-SHOE at test. The different surface forms of stimuli share conceptual representations; they do not share perceptual representations as they have physically different forms. Therefore, priming on the picture-word matching task depends upon perceptual (domain-specific) and not conceptual representations. These results are consistent with previous experiments that have examined cross-modal and cross-domain repetition priming effects. Such changes are associated with significant attenuation, and often elimination, of priming (e.g. Ellis *et al.*, 1987; Kroll & Potter, 1984; Morton, 1979; Winnick & Daniel, 1970).

The results of Experiment 5 raise an important question concerning the results of the experiments described in the last chapter, in which the pairings of items were recombined between training phase and test phase encounters. Morton (1979) described separate systems for the recognition of visually presented words, heard words and visually presented pictures. Each has its own representation of an item, used to recognise that item whenever it is encountered in that modality and domain. Schacter (1992b; Tulving & Schacter, 1990) similarly described the structure of pictures and words as being processed by different subsystems of the perceptual representation system, namely the structural description system and the word form system. One could speculate that the apparent independence of the memory representations underlying the repetition effect described in Experiments 1, 2 and 3 may be *by virtue* of the fact that the stimuli presented as a pair were from different domains. One was a picture and the other a word, and according to Morton (1979) and Schacter (1992b) they would be dealt with by different processing (sub)systems. It may not be possible to associate items from different domains in such a way that they are represented together in the kind of memory upon which the repetition priming effect depends. It is less clear what the effect of recombining pairs of simultaneously presented items from *within* the domain of object pictures or words would be. Here the two stimuli would be dealt with by the same subsystem of the perceptual representation system. It is possible that *within* each subsystem each perceptual event might be stored as a specific instance, and the priming effect depends upon episodic retrieval of that event upon repetition. The priming effect may therefore be sensitive to the novel pairing of two items from the same domain, such as two object pictures, even though it is not sensitive to the pairing of a picture and a word. Alternatively, the representations within a domain, that is, within a subsystem of the perceptual representation system, could still be dedicated to representing *individual* items, for the purposes of identification, and not entire perceptual events. In this case, the pattern of results observed in Experiments 1, 2 and 3 follows from the fact that the picture and word in a pair have separate identities, not from the fact that they are drawn from separate domains.

These two possible explanations of the independence of the representations of the simultaneously presented stimuli were confounded in Experiments 1, 2 and 3. Experiment 6 was conducted to address this issue. Subjects again performed a speeded same/different matching task, this time to pairs of stimuli all drawn from within the domain of object pictures. Again, the effect upon latencies of responses at test of re-pairing the stimuli between training and test was examined.

Experiment 6

The design of Experiment 6 was essentially the same as that of Experiment 3. Here, however, on each trial a pair of object pictures was presented rather than a picture and an object name. In the case of same pairs, the pictures were two different views of the same object, or were two different exemplars of the same "entry-level category" (Jolicoeur, Gluck & Kosslyn, 1984), i.e. two items that would normally have the same name. In different pairs, the two pictures were of unrelated objects. Again the task was one of speeded same/different matching.

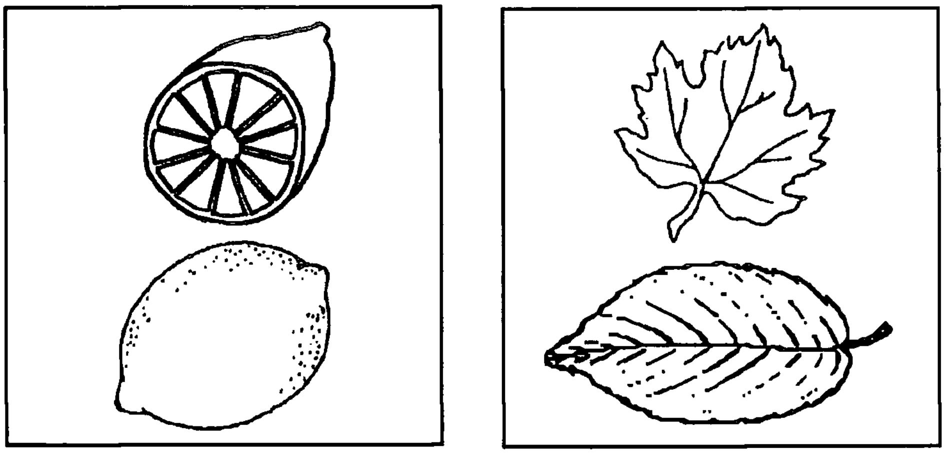
METHOD

Subjects. There were 16 subjects, all members of the MRC Applied Psychology Unit subject panel, mean age 29.2 years, range 17-37. All had normal or corrected-to-normal vision.

Materials. Materials were selected and organised into sets as in Experiment 3. The *same* pairs containing two line drawings of the same object, one taken from Snodgrass and Vanderwart (1980, Appendix A), the other purpose drawn. The purpose drawn pictures represented different views of the same object or different exemplars of the same "entry-level category", i.e. an object that would normally have the same name. Two examples of same pairs are given in Figure 3.3. The *different* pairs contained line drawings of different objects, taken from Snodgrass and Vanderwart (1980, Appendix A).

Design and Procedure. The experiment consisted of two phases, a training phase and a test phase. These ran consecutively and subjects performed the same task in each. They were not told of the distinction between the two phases.

Figure 3.3. *Examples of Two Same Object Picture Pairs Used in Experiment 6.*



Each subject was tested individually. Stimulus pairs comprising two line drawings of objects (scaled to each subtend a visual angle of 4.6° vertically; mean 5.9°, range 2.3-9.1° horizontally) were presented on the monitor. One picture was presented directly above the other, separated by a visual angle of 1.1°. For the same pairs, in half the trials the Snodgrass and Vanderwart (1980, Appendix A) picture was presented above the purpose drawn picture and in half the trials vice versa. Subjects were required to respond by pressing one of two alternative computer keys (keys "M" and "Z") to indicate whether the two pictures were of the same kind of object (e.g. a vintage car and a saloon car) or were of different objects. Following a response, the screen was cleared and the next pair of pictures presented after an interval of 1500 msec. Instructions stressed that responses should be made as quickly as possible, but not at the expense of accuracy.

Practice with 4 filler pairs preceded the training phase, in which one of the same sets and two of the different sets were presented, along with 20 same filler pairs and 10 different filler pairs, in a random order. There were thus an equal number of "same" and "different" responses required during the training phase. This phase lasted approximately three minutes.

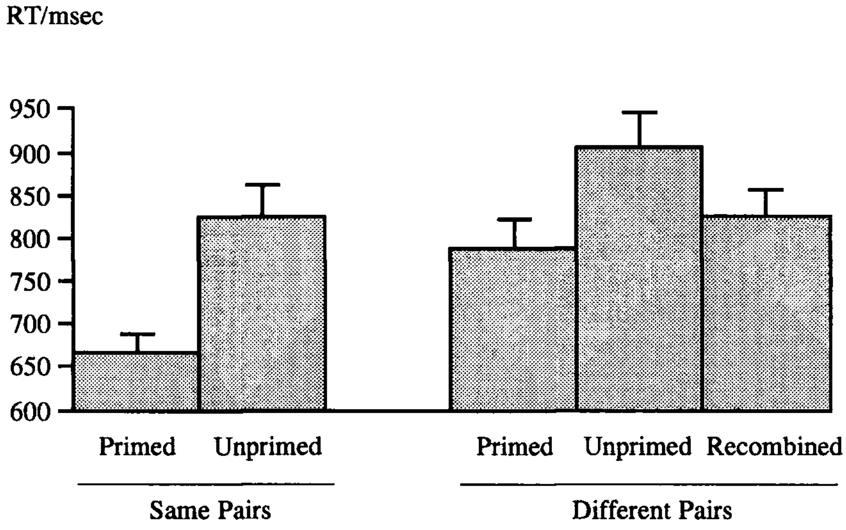
The test phase carried on directly from the training phase. The same set and one of the different sets presented during training were re-presented in the test phase. These are referred to as the *primed same* items and the *primed different* items. A previously unseen same set and a previously unseen different set were also presented, referred to as *unprimed same* items and *unprimed different* items. The items in the remaining different set presented during training were recombined, to give new pairings of unrelated pictures, and were presented in the test phase. For these recombined pairs, both items within each had therefore been seen before, but not paired with each other. These are referred to as *recombined different* items.

Ten same filler pairs that were presented during the training phase were re-presented in the test phase, along with a further 10 same filler pairs and 10 different filler pairs. Thus in the test phase, an equal number of "same" and "different" responses were required, and to items that were repeated from the training phase, an equal number of each response was required. The test phase lasted approximately three minutes. All pairs were presented in a random order within each phase, with a different order used for each subject. Materials were rotated between sets across subjects.

RESULTS

Again, the measure of interest in Experiment 6 was the latency of correct responses made to different types of picture-picture pairs in the test phase. Figure 3.4 shows the mean correct response latency in milliseconds to each item type. Appendix 6 includes the standard deviations associated with these means, the percentage of response latencies over 2000 msec and the mean percent error rate to each item type. Latencies over 2000 msec (1.38% of responses) and latencies of incorrect responses (4.06% of remaining responses) were excluded from the mean response latencies. Analysis of the arc-sine transformed proportions of response latencies over 2000 msec revealed no significant difference between the primed same pairs and the unprimed same pairs (p>.1), or between the three types of different pair (p>.1). There was no significant difference in the arc-sine transformed error rates for primed same pairs and unprimed same pairs (p>.1), and no significant differences in the arc-sine transformed rates of errors made to the three types of different pair (p>.1). There was no apparent speed-accuracy trade-off in subjects' responding.

Figure 3.4. *Experiment 6. Mean Test Phase Correct Response Latencies (in Milliseconds).* Bars indicate the standard errors of the means.



Separate one factor within-subjects and within-items analyses of variance (denoted by the subscripts $_1$ and $_2$ respectively) were carried out on the latencies of responses made to same pairs and to different pairs in the test phase of the experiment. For same pairs, there was a significant effect of priming the items, $F_1(1,15)=37.77$, $p<.0001$; $F_2(1,19)=28.10$, $p<.0001$, primed same items being responded to more quickly than unprimed same items. For different pairs, there was a significant effect of item type, $F_1(2,30)=12.63$, $p=.0001$; $F_2(2,78)=11.60$, $p<.0001$. Differences between individual means were examined using post hoc Newman-Keuls tests. There was a simple repetition priming effect, i.e. primed different pairs were responded to significantly faster than the unprimed different pairs ($p_1<.01$;

$p_2 < .01$). The recombined different pairs too were responded to faster than the unprimed different pairs ($p_1 < .01$; $p_2 < .01$). There was no significant effect of recombining the items within a pair; response latencies to the recombined different and primed different pairs did not differ statistically ($p_1 > .1$; $p_2 > .1$). There was thus no significant effect upon response latencies of changing the pairings of pictures between training and test.

DISCUSSION

Experiment 6 extends the findings of Experiments 1, 2 and 3, revealing no significant effect of recombining pairs of simultaneously presented stimuli between training and test when all stimuli were from within a single domain.

Again it is necessary to express the cautions associated with drawing conclusions from a null result (the finding of *no significant difference* between response latencies to primed different and recombined different pairs). In Experiment 6 this difference was larger, both in absolute terms and as a percentage increase over latencies to unprimed items, than that observed in Experiments 1, 2 and 3. It was, however, still not reliable. (The critical difference required for observing a statistically significant effect ($p < .05$) on the Newman-Keuls test in this case was 50 msec, the observed difference was 38 msec. The p-value associated with the observed difference is 0.12.) While there was no significant advantage in responding to the primed different pairs over the recombined different pairs, there was a larger and significant advantage in responding to both of these types of stimuli as compared to the unprimed pairs. The facilitation of both the primed different pairs and the recombined different pairs is not a null result, and requires explanation. Activation of pre-semantic item-specific representations provides the best account of these priming effects, while any contribution from the retrieval of prior processing episodes is at best minor.

Experiment 5 revealed no priming between domains, i.e. between picture and word forms. This, however, could not account for the independence of representations underlying the priming effect observed in Experiment 6, as stimuli were all from within a single domain. The results of Experiment 6 are consistent with the view that the representations underlying the priming effect are representations of individual stimuli. They do not contain any information about the pairings of stimuli, even when stimuli are from a single domain and representations would be within a single subsystem of that cognitive system responsible for the initial identification of stimuli, as described by Morton (1979) and Tulving and Schacter (1990).

GENERAL DISCUSSION

The results of the experiments reported in this chapter provide important refinements to the conclusions that can be drawn on the basis of the experiments reported in the last chapter. Together, Experiments 1, 2, 3, 4, 5 and 6 provide evidence for the activation of item-specific perceptual representations as a locus of the repetition priming effect. They suggest a negligible role, if any, for the retrieval of prior processing episodes. This series of experiments examined the nature of the representations underlying repetition priming of pairs of stimuli presented simultaneously, using a speeded same/different matching task. The main findings can be summarised as follows: There was no significant attenuation of the priming effect when the pairings of pictures and words presented together were changed between training and test phases of the experiment (Experiments 1 and 3). This result also held when the training task required explicit consideration of the relation between semantic properties of the two items in each pair (Experiment 2). Subjects were able to remember the pairings at well above chance levels (Experiment 4), so it cannot simply be the case that they were unable to retain the associations between items given the training conditions. Rather, it is clear that the particular representations underlying the observed repetition priming effect encode item-specific and not associative information. There was no cross-domain priming, i.e. between pictures and words and vice versa (Experiment 5), revealing that the representations involved are perceptual, not conceptual, in nature. Finally, the difference in priming of pairs recombined between training and test and pairs repeated intact was not reliable when both items were taken from the domain of object pictures (Experiment 6). The independence of the representations underlying the effect was therefore not contingent upon the two items belonging to separate domains; the representations were item-specific within a domain.

These findings present problems for theories of repetition priming according to which the effect results only from retrieval of records of entire processing episodes (Jacoby, 1983a, 1983b; Jacoby & Brooks, 1984), or the closely related view that the effect results from the reinstatement of prior processing demands (Roediger & Blaxton, 1987a, 1987b). This class of theory predicts that recombining pairs of stimuli, initially presented together, should attenuate the repetition priming effect; the recombined pair of items would act as a less efficient retrieval cue for the earlier processing episode, or reinstate less exactly the prior processing demands, than does the original pair of stimuli repeated together. In none of experiments were significant differences in priming between repeated and recombined pairs detected.

The perceptual representation system, deemed to be the locus of the repetition effects observed in these experiments, serves to represent stimuli for the purposes of identification. Not all classes of information are pertinent to this task. It follows that constraints should be placed on the types of information for which it is possible to demonstrate repetition effects, depending upon their role in the processes leading to the identification of stimuli. For example, Ellis *et al.* (1990) examined repetition priming of familiar faces following sex decisions, expression decisions and familiarity decisions. Of these three tasks, only familiarity decisions required that the face be identified. Performing a sex or an expression decision to a face at training, followed by the same decision to the same face at test, did not result in any benefit in response time. However, sex or expression decisions did prime subsequent familiarity decisions to the face - in fact, just as much as making a familiarity decision at the first, training encounter.

Ellis *et al.* (1990) pointed out that their results are consistent with priming occurring within the system that responds to the identity of a face. Sex decision and expression decisions about a face do not require the use of this system, and hence there is no benefit in making these decisions a second time. Making a sex or an expression decision to a familiar face at training does, however, automatically result in that face being recognised, i.e. its representation in the system that responds to the identity of a face is activated. Therefore, sex and expression decision result in repetition priming in a subsequent familiarity decision task that requires the use of this representation. Ellis *et al.*'s (1990) findings are not consistent with theories that argue that repetition priming results from the reinstatement of the processing demands of the training encounter at test. These theories predict that when the test phase task is one of familiarity decision, changing the training phase task (and therefore the degree to which processing demands are reinstated) from familiarity to sex or expression decision should attenuate the priming effect observed. This pattern of results was not observed. The findings of Ellis *et al.* (1990) thus reveal a constraint upon the types of task on which repetition effects for faces can be demonstrated, depending upon the role of the processes leading to the identification of stimuli in these tasks.

The results of the experiments reported thus far in this thesis also reveal a constraint upon the occurrence of repetition priming consistent with, as Ellis *et al.* (1990) concluded, a locus of the effect being a system dedicated to the identification of individual items. The *pairings* of two items presented simultaneously are not represented in the system deemed to be the locus of the repetition effect. While subjects are still able to remember having seen these pairings, such arbitrary novel associations are irrelevant to the task of word or object identification.

In drawing attention to an item-specific locus of repetition priming in the recognition system, it is not meant to be implied that this is the only possible locus of repetition effects. In other tasks, processing may require the use of other systems where repetition priming can occur. For example, Wheeldon and Monsell (1992) argue that repetition priming can occur in processes of stimulus production as well as recognition. They found facilitation in latencies to name pictures of objects when those names had recently been read aloud or produced in response to a definition. The locus of the priming effect could not be in the activation of representations used for stimulus identification, because the pictures, read words and definitions would not share these representations. They do, however, share spoken word forms. Producing a homophone of an object name did not prime naming of that object picture, so the locus of the effect could not be the activation of phonological forms. It was concluded that repetition priming resulted from changes in the connections between representations of meaning and spoken word form. Any influence of repetition priming at this locus was eliminated in the experiments reported here by using a matching task which did not require overt naming. Matches based on representations of identity or semantic properties rather than names are more likely in a speeded task, as name retrieval is a more time consuming process (Potter & Faulconer, 1975).

As well as not wanting to imply that the item-specific locus identified here is the only locus of repetition priming, nor should it be taken that the retrieval of prior processing episodes *never* plays a role when repetition priming effects are observed. There is evidence that it can play such a role when exceptional demands are placed on stimulus encoding mechanisms, for example, in the re-reading speed of inverted text (Kolers, 1975), or in priming on lexical decision and naming tasks of handwritten words (Brown & Carr, 1993). Rather, the results of Experiments 1, 2, 3, 4, 5 and 6 reveal that retrieval of prior processing episodes, or the reinstatement of prior processing demands, is insufficient as a general account of *all* repetition effects.

4

TESTING A PREDICTION: IS THE REPETITION PRIMING EFFECT INDEPENDENT OF DECISION AND RESPONSE?

INTRODUCTION

On the basis of the experiments described in Chapters 2 and 3, a locus of the repetition priming effect was described. This locus is a system that represents individual visual objects or words for the purposes of recognition. These representations are item-specific, as it was shown that recombining pairings of items between an initial training phase encounter and a subsequent test phase encounter did not attenuate the facilitation of responding to repeated stimuli at test. What appeared to matter was the fact that the stimulus pair contained two items that were seen during training, not whether they were seen together (Experiments 1, 2, 3 & 6). The representations underlying the priming effect are also perceptual in nature; they are not shared by a picture of an object and a word that share the same identity in terms of meaning (Experiment 5).

The representations underlying the priming effect are described as containing only information necessary for the purposes of stimulus identification. Information about processing that is performed subsequent to stimulus identification, such as decisions made on the basis of task instructions and the selection and execution of a response, would not be encoded in these representations. It follows from such an item-specific representation account that manipulating such variables, that is, changing the decision to be made about a stimulus item and the response to be executed between training and test encounters, should not affect repetition priming. In contrast, an account of the priming effect based on the retrieval of prior processing episodes would predict effects of such manipulations. According to such an account, when an item is repeated at test, any change in the decision made about it, or the selection and execution of a response made on the basis of that decision, will mean that the test encounter with that item will act as a less efficient retrieval cue for its training encounter. The priming effect should be sensitive to the integrity of stimulus-decision and stimulus-response mappings between training and test. The effects of changing these mappings were investigated in the experiments described in this chapter.

There is evidence that the learning of stimulus-response or stimulus-decision mappings is a significant factor in the facilitation of responding to stimuli following *many* repetitions (Schneider & Shiffrin, 1977). There is less clear evidence that stimulus-response or stimulus-decision mappings learned after a single trial play a role in producing the repetition priming effect.

Logan (1990, Experiments 1 & 2) found that simply swapping whether response keys were pressed with the index finger of the right hand or of the left hand, between training and test, had no effect upon priming of words in a lexical decision task. Information about the response associated with particular stimulus items does not appear to be encoded in the representations underlying the repetition priming effect.

A number of studies have failed to find an effect of changing the task performed between training and test upon repetition priming. A change in task produces a change in the *decision* made to repeated stimuli. Ellis *et al.* (1990) found that making sex decisions or expression decisions to faces at training primed subsequent familiarity decisions just as much as when a familiarity decision task (which would be identical to the test task) was performed at training. The change in task did not attenuate the priming effect. Valentine, Moore, Flude, Young and Ellis (1993) found, using word stimuli that could be either surnames or common nouns, that making name familiarity decisions primed subsequent lexical decisions just as much as if the training task had also been one of lexical decision. Similarly, lexical decisions made at training primed subsequent name familiarity decisions just as much as did name familiarity decisions performed at training. It must also be noted that in the present thesis, changing the training phase task from one based on matching the identities of pictures and words simultaneously presented (Experiment 1) to one based on matching the categories into which the two items fell (Experiment 2) did not significantly affect the magnitude or the pattern of priming effects observed in the identity-matching task at test.

Repetition priming, in the experiments discussed above, appears to be determined by the fact that items at test have been *recognised* in the training phase of the experiment. Repetition of other aspects of the tasks being performed, such as the particular decision made about each item on the basis of task instructions, or the selection and execution of a response, does not play a role in facilitating processing of the stimuli.

Logan (1990) provided evidence, however, to suggest that stimulus-decision associations do play a role in performance on priming tasks. He observed less priming of pronunciation decisions at test following lexical decisions made to the same items during training, than following the same pronunciation decision task at training (Experiments 3 & 4). Lexical decisions require responses to indicate whether a letter string is a real word or a nonword; pronunciation decisions require responses to indicate whether a letter string is pronounceable or unpronounceable. Changing the task to be performed between training and test was described as changing the interpretation of each stimulus item from one in terms of lexicality to one in terms of pronounceability. In the condition where there was no change in task there was no change in the interpretation of each stimulus item. Consistent with this evidence, Durso and Johnson (1979) found more priming of object picture naming at test following picture naming at training than following reading of the object names aloud. Lachman and Lachman (1980) found more priming of object picture naming at test following picture naming at training than following responding to pictures as distractor items in a recognition memory test.

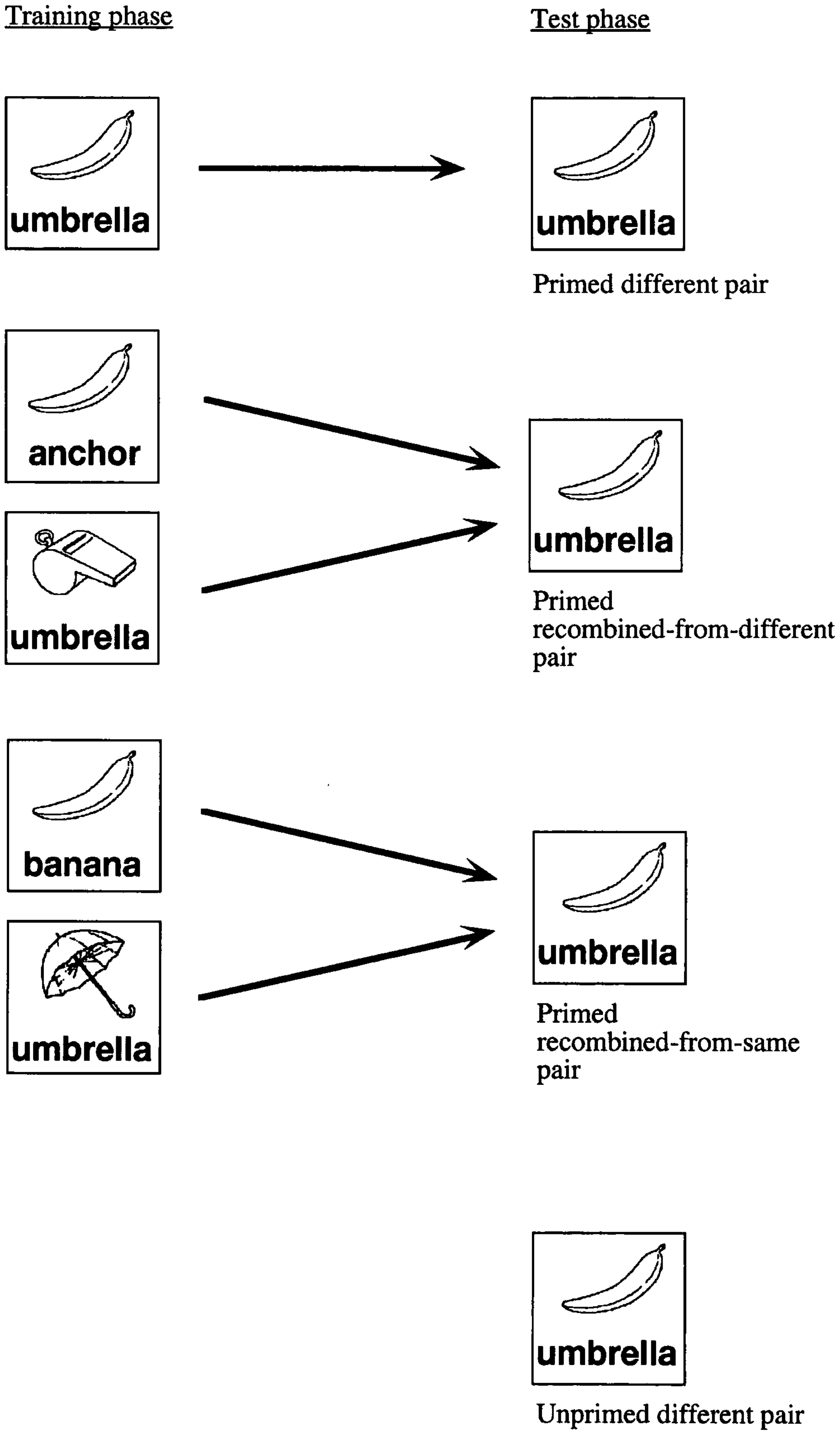
These results can, however, also be accounted for without arguing that the memory representations underlying the priming effect contain information about the interpretation of stimuli. For example, in the case of Logan's (1990) experiments, performing lexical decisions and pronunciation decisions will both result in the activation of representations of the perceptual structure and form of each item. Lexical decisions can be made on the basis of whether the item has a familiar perceptual structure (i.e., is a word) or not. Pronunciation decisions are made on the basis of a set of processes not required by the lexical decision task - those involved in producing phonological forms from orthographic forms. If repetition priming can result from activation of representations used in word recognition *and* representations used in name production (cf. Wheeldon & Monsell, 1992), then we would predict the pattern of results obtained by Logan without arguing that the representations at either locus contain information about entire processing episodes. Performing the pronunciation decision task at training would activate representations at both loci and so there would be two contributions to the benefit in response latency when pronunciation decisions are made at test. On the other hand, performing the lexical decision task at training would result in activation of representations at only the first locus, and hence would facilitate subsequent pronunciation decisions to a lesser degree. (A prediction would be that had Logan examined the effects of changing task from pronunciation decisions at training to lexical decisions at test, no attenuation of the priming effect would have been observed.) Phrased in these terms, repetition priming is attenuated not by a change in stimulus-interpretation mappings, but by different sources of facilitation in responding being available with different task demands. Information about the decision made to each item need not be stored in the representations at either of the loci described.

Similarly, while Durso and Johnson (1979) found more priming of picture naming following picture naming at training than following reading of the object names aloud, in the first condition both loci of the priming effect would have contributed to the facilitation in responding at test. In the latter condition only the activation of representations involved in name production, and not stimulus identification, would have contributed. While Lachman and Lachman (1980) found more priming of object picture naming after performance of that same task at training than after responding to the pictures as distractors in a recognition memory test, in the first condition both loci of the priming effect would have contributed to the facilitation in responding at test, in the latter condition only the activation of representations involved in stimulus identification, and not name production, would have contributed.

In the experiments performed by Ellis *et al.* (1990) and by Valentine *et al.* (1993), and in Experiments 1 and 2 of this thesis, there is no confounding of changes in task between training and test with changes in the number of loci of repetition priming potentially contributing to task performance. In the three examples given above, the test phase tasks can be seen to require processes involved in the representation of individual stimuli for the purposes of identification. They do not additionally require processes involved in the representation of individual items for the purposes of name production. In these studies there were no effects of changing stimulus-decision mappings between training and test phases upon repetition priming. These results therefore pose problems for accounts of the repetition priming effect based on the retrieval of prior processing episodes, while being consistent with accounts based on the activation of item-specific representations.

Experiment 7 was performed to investigate the effects upon repetition priming of changing both stimulus-decision and stimulus-response mappings between training and test in the speeded same/different matching task used in Experiments 1, 2, 3, 5 and 6. The experiment was essentially the same as Experiment 3, but with the addition of a new type of stimulus pair. At the item-specific locus of the priming effect described on the basis of the experiments in the previous two chapters, there will be separate representations of the picture and the word in a *same* pair; despite the fact that they have the same identity at a semantic level, the picture and the word have separate *perceptual* identities and will have separate representations dedicated to their structure and form for the purposes of initial identification. It follows that a test phase *different* pair containing a picture that was seen as part of a training phase same pair and containing a word that was seen as part as a second training phase same pair should be primed just as much as a different pair repeated verbatim from the training phase. This is the specific hypothesis of Experiment 7. These *recombined-from-same* pairs contain two items that would have separate pre-semantic, item-specific representations and that were identified during training, just like the recombined different pairs (renamed here recombined-from-different pairs) used in Experiments 1, 2, 3 and 6. The recombined-from-same pairs, however, also require a different decision and response to be made at test than was made in the training phase. The primed different and the recombined-from-different pairs do not require such a change in response. Therefore, the prediction that the recombined-from-same pairs should be primed just as much as the primed different and the recombined-from-different pairs when repeated is contingent upon there being no role of stimulus-response or stimulus-decision mappings in producing the priming effect: a prediction of an item-specific account but not an episodic account of repetition priming. Figure 4.1 gives examples of the four critical types of test phase different pair presented in Experiment 7.

Figure 4.1 *Examples of different pair stimuli used in Experiment 7*



Experiment 7

METHOD

Subjects. There were 16 subjects, all undergraduate or postgraduate students with normal or corrected-to-normal vision.

Materials. One hundred items were taken from Snodgrass and Vanderwart (1980). These items comprise line drawings of familiar objects and their written names. They were divided into 10 sets, each containing 10 items, as in Experiment 1. The sets were matched for measures of name agreement, image agreement, familiarity, complexity and object name frequency. The means and standard deviations of each of these ratings for each of the 10 sets of stimuli are given in Appendix 1.

These materials were organised to produce pairs consisting of a line drawing of an object (Snodgrass & Vanderwart, 1980, Appendix A) and an object name. There were four sets of 10 *same* pairs containing the line drawing of an object along with its correct name. Three sets of 10 *different* pairs contained the line drawing of an object along with an unrelated name. A set of filler pairs (32 same pairs and 32 different pairs) was developed from remaining Snodgrass and Vanderwart items.

Design and Procedure. The experiment consisted of two phases, a training phase and a test phase. These ran consecutively and subjects performed the same task in each. They were not told of the distinction between the two phases.

Each subject was tested individually, viewing a computer monitor at a distance of approximately 50 cm. Stimulus pairs comprising a line drawing of an object (scaled to subtend a visual angle of 6.3° vertically and ranging 2.3°-10.9° horizontally) and an object name (lower case, bold helvetica font, subtending a visual angle of 1.7° vertically and ranging 3.4°-9.7° horizontally) were presented on the monitor. The picture was presented with, and directly above, the name (separated by a visual angle of 1.1°). Subjects were required to respond by pressing one of two keys on the computer keyboard to indicate whether the picture and the name referred to the same object or to different objects. All subjects responded with the right index finger on key "M" to indicate a "same" match and with the left index finger on key "Z" to indicate a "different" match. Following a response, the screen was cleared and the next picture-word pair presented after an interval of 1500 milliseconds. Instructions stressed that responses should be made as quickly as possible, but not at the expense of accuracy.

Practice with 4 filler pairs preceded the training phase, in which three of the same sets and two of the different sets were presented, along with 10 same filler pairs and 20 different filler pairs, in a random order. There were thus an equal number of "same" and "different" responses required. The training phase lasted approximately three minutes.

The test phase carried on directly from the training phase. One of the same sets and one of the different sets presented during training were re-presented in the test phase. These are referred to as the *primed same* pairs and the *primed different* pairs. A previously unseen same set and a previously unseen different set were also presented, referred to as *unprimed same* pairs and *unprimed different* pairs. The items in the remaining different set presented during training were recombined to give new pairings of an object picture and an unrelated name and were presented in the test phase. For these recombined pairs, both items within each had therefore been seen before, but not paired with each other. These are referred to as *recombined-from-different* pairs. The items in the two remaining same sets presented during training were also recombined to give pairings of object pictures and unrelated object names, that is, to form a single different set which was presented in the test phase. Again, both items within the pairs in this set had been seen during training, but not paired with each other. These are referred to as *recombined-from-same* pairs.

Ten same filler pairs that were presented during the training phase were re-presented in the test phase, along with a further 20 same filler pairs and 10 different filler pairs. Thus in the test phase, an equal number of "same" and "different" responses were required. The test phase lasted approximately seven minutes. All pairs were presented in a random order within each phase, with a different order used for each subject. The design of Experiment 7 is summarised in Table 4.1.

Table 4.1. *Summary Experimental Design for Experiment 7.*

Phase		
Training		Test
10 same pairs	→	10 primed same pairs
10 different pairs	→	10 primed different pairs
10 different pairs	→	10 recombined-from-different pairs
20 same pairs	→	10 recombined-from-same pairs
		10 unprimed same pairs
		10 unprimed different pairs
10 same filler pairs	→	10 same filler pairs
20 different filler pairs		
		20 same filler pairs
		10 different filler pairs

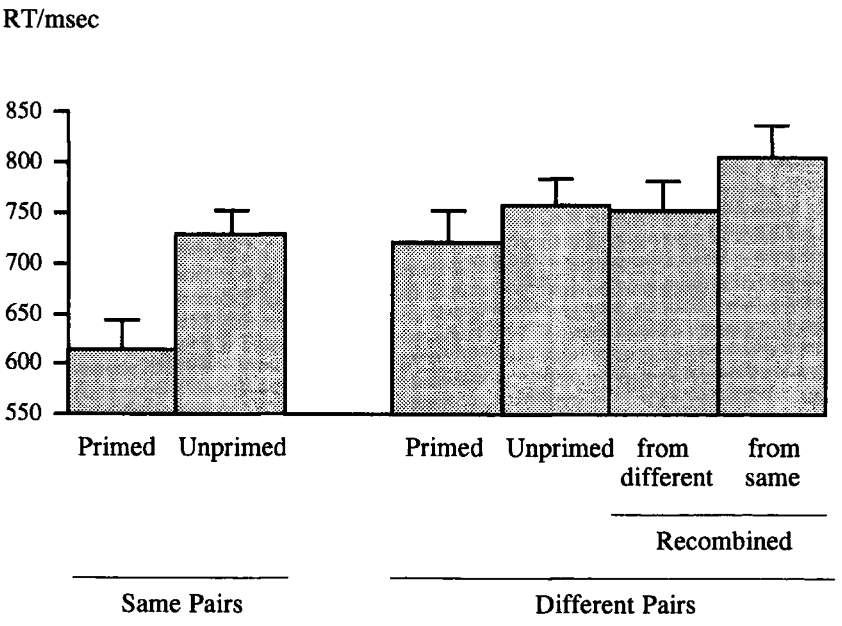
Same pairs contained an object picture along with its correct written name. Different pairs contained an object picture along with an unrelated written name. Primed pairs were repeated from the training phase of the experiment in the test phase. One set of 10 same filler pairs were also repeated from the training phase in the test phase.

Materials were rotated between sets across subjects. Same pairs were rotated between the primed and the unprimed sets; thus eight subjects responded to each same pair in each of these conditions. Different pairs were rotated between the primed, unprimed, recombined-from-different and the recombined-from-same sets; thus four subjects responded to each different pair in each condition.

RESULTS

The measure of interest in Experiment 7 was the latency of correct responses made to picture-name pairs in the test phase. Figure 4.2 shows the mean correct response latency in milliseconds to each type of item. Appendix 7 includes the standard deviations associated with these means, the percentage of response latencies over 2000 milliseconds and the mean percent error rate to each item type. Latencies over 2000 milliseconds (0.52% of responses) and latencies of incorrect responses (3.04% of remaining responses) were excluded from the mean response latencies.

Figure 4.2. *Experiment 7. Mean Test Phase Correct Response Latencies (in Milliseconds).* Bars indicate the standard errors of the means.



Analysis of the arc-sine transformed proportions of response latencies over 2000 milliseconds revealed no significant difference between the primed same pairs and the unprimed same pairs ($p>.1$), or between the three types of different pair ($p>.1$). There was no significant difference in the error rates for primed same pairs and unprimed same pairs ($p>.1$), and no significant differences in rates of errors made to the three types of different pair ($p>.1$).

Separate one factor within-subjects (F_1) and within-items (F_2) analyses of variance (ANOVAs) were carried out on the response latencies to same pairs and to different pairs. For same pairs, there was a significant effect of priming the items, $F_1(1,15)=15.654$, $p<.01$; $F_2(1,19)=28.583$, $p<.0001$, with primed same pairs being responded to more quickly than unprimed same pairs. For different pairs, there was a significant effect of item type, $F_1(3,45)=9.704$, $p<.0001$; $F_2(3,117)=5.167$, $p<.01$. Differences between individual means were examined using post hoc Newman-Keuls tests. The response latencies made to primed different pairs did not significantly differ from those made to unprimed different pairs ($p_1>.1$; $p_2>.1$); that is, there was no statistically significant facilitation in responding in the test phase to pairs of items simply repeated from the training phase. Latencies of responses made to recombined-from-different pairs did not significantly differ from those made to primed different pairs ($p_1>.1$; $p_2>.1$), nor did they differ from responses made to unprimed different pairs ($p_1>.1$; $p_2>.1$).

Experiment 7 differed from Experiment 3 in the addition of a set of items, namely the recombined-from-same pairs. These were responded to significantly more slowly than the other three types of different pair: the primed different pairs ($p_1<.01$; $p_2<.01$), the recombined-from-different pairs ($p_1<.01$; $p_2<.05$) and the unprimed different pairs ($p_1<.01$; $p_2<.05$). There was therefore significant *inhibition* of responding to the recombined-from-same pairs, relative to the response latencies made to the unprimed different pairs.

DISCUSSION

Experiment 7 differed from Experiment 3 only in the addition of a further set of items, described as the recombined-from-same pairs. Both the picture and the word in these pairs had been seen in the training phase of the experiment, but as members of two pairs that each required a "same" response, rather than being paired with each other. The principal focus of Experiment 7 was the extent to which responding to the recombined-from-same pairs was facilitated in the test phase; responses to these stimuli were in fact made more slowly than responses to stimuli not presented during the training phase. This difference was revealed by both analyses by-subjects and by-items. It must also be noted that the pattern of significant differences between the three other types of different pair, which were also presented in Experiment 3, was not the same as the pattern that occurred in that earlier experiment; the addition of the recombined-from-same pairs appeared to affect subjects' responding to these other types of stimuli. The inhibition of responses made to the recombined-from-same pairs and the effects of introducing these items on responses to the other items will be considered in turn.

The significant inhibition of responding to the recombined-from-same pairs is not predicted by an item-specific representation account of the priming effect, despite such an account having accommodated the results of the experiments described so far in this thesis, and which used the same task. In the previous experiments, equivalent facilitation in responding to primed different pairs and recombined different pairs was observed, and it was argued that this resulted from the fact that both types of stimulus contained a picture and a word that had been recognised during the training phase. The recombined-from-same pairs included in Experiment 7 also contained a picture and a word that had been seen during the training phase. Therefore, just as much priming upon repetition was predicted for these items as occurred for the primed different and the recombined-from-different pairs, despite the fact that they also required a change in the response to be made between training and test. Information about processing subsequent to the identification of stimuli is deemed not to be incorporated into the item-specific representation underlying the priming effect. The observed inhibition of the recombined-from-same pairs would therefore seem to pose difficulties such an account of the effect.

The inhibition of responses to the recombined-from-same pairs is, on the other hand, consistent with an account of repetition priming based on the retrieval of entire processing episodes, or the reinstatement of prior processing demands. The response made to a stimulus is part of the processing episode with that stimulus. There is less overlap between the processing demands of training and test for the recombined-from-same pairs (change in pairings and response) than for the primed different pairs (no change in pairings or response) or for the recombined-from-different pairs (change in pairings only). Therefore, of these three stimulus types, the recombined-from-same pairs would act as the least efficient retrieval cues for training phase processing episodes, and should therefore be facilitated the least as a result of repetition. The fact that the recombined-from-same pairs required a "different" response, but would act as retrieval cues for training episodes incorporating a "same" response, could account for their being responded to more slowly than even the unprimed different pairs. This result would be expected if changing the response associated with a stimulus is more time consuming than responding to a stimulus that has no prior response associated with it.

There is another possible explanation for the inhibition of responding to these stimuli added in Experiment 7. Inhibition in the processing of an item has been described as a result of subjects' use of effortful memory strategies, rather than reflecting automatic processes. This distinction has been made with reference to semantic priming (e.g. Neely, 1991) and speeded recognition memory (Ratcliff & McKoon, 1981) as well as to repetition priming over relatively short SOAs (Posner & Snyder, 1975a, 1975b) and over long delays with many intervening items (Warren & Morton, 1982). In tasks where a target item appears on the trial following the prime, subjects may generate expectancies about the occurrence of the target item on the basis of the item that preceded it, or they may examine each target for a relationship with the preceding item. Both of these strategies take time and result in slower response latencies to unexpected or unrelated items than to items preceded by a neutral prime. Warren and Morton (1982) suggested that in a perceptual identification task (Experiment 1), subjects were using conscious memory for trained items in an attempt to find a match for the degraded target. When non-identical pictures of objects were repeated, the lack of an exact match produced some inhibition in the identification of that picture, which reduced the degree to which non-identical pictures were facilitated relative to identical pictures.

It is possible that subjects' use of explicit memory also produced the inhibition of responding to the recombined-from-same pairs seen in Experiment 7. The change in response between training and test that the recombined-from-same pairs required may have been particularly salient and, in becoming aware of this, subjects' responding to these items was delayed.

Since Experiment 7 differed from Experiment 3 only in the addition of one type of stimulus item, it was expected that the pattern of responses to the types of item common to both experiments would be the same. In Experiment 3, the primed different and the recombined different (equivalent to the recombined-from-different) pairs were responded to significantly faster than the unprimed different pairs. In Experiment 7 they were not: the addition of the third type of repeated stimulus pair resulted in the priming of the other two types being eliminated. If differences in response latencies reflect automatic priming effects, this outcome would not be expected. It might be expected, however, if subjects scrutinised the primed different pairs and recombined-from-different pairs for a change in response between training and test, as was suggested they do with the recombined-from-same pairs. Such circumstances are not incompatible with facilitation in the processing of repeated items resulting from the activation of item-specific perceptual representations; such benefits are masked behind the detriment in response time resulting from the use of explicit memory.

It remains, then, to demonstrate that task performance in Experiment 7 was determined in part by subjects' use of explicit memory. In the semantic priming literature, strategic effects can be revealed by the *proportion effect* (Tweedy, Lapinski & Schvaneveldt, 1977; den Heyer, Briand & Dannenbring, 1983). Semantic priming increases as the proportion of related prime-target trials is increased in the experiment. The greater this proportion is, the more likely subjects are to notice that some trials are related, and the greater the utility of an explicit strategy. The priming effect increases due to both facilitated processing of targets preceded by related primes, and due to increased inhibition of unrelated or unexpected targets. If the explicit memory hypothesis is correct *a propos* Experiment 7, it follows that the inhibition of the recombined-from-same pairs should be reduced as the proportion of items that are repeated in the experiment is decreased. The reaction time advantage for the primed different pairs and the recombined-from-different pairs over the unprimed different pairs should increase. On the other hand, a lack of a proportion effect on the pattern of response latencies observed would suggest that information about the response to be made to a stimulus pair is automatically retrieved from the memory representations underlying the priming effect.

A repetition priming experiment in which the ratio of studied to nonstudied items at test was manipulated was mentioned in Chapter 1. Jacoby (1983b) found that this variable affected the magnitude of priming in a perceptual identification task; there was more priming of repeated words when they constituted 90% of the items than when they constituted only 10%. This result was taken as evidence for an episodic account of the repetition priming effect. With the addition of filler items, the context in which each primed item occurred at test is less like that in which it occurred at training. Therefore, in the condition with more filler items, repeated words act as less efficient retrieval cues for earlier processing episodes than they do in the condition with less filler pairs. This effect is described as occurring independently of explicit recognition and recall of the items (Allen & Jacoby, 1990). An episodic account therefore predicts the opposite pattern of results to the hypothesis that explicit memory acts as a basis for responding. If the use of explicit memory as a basis for responding led to there being no significant facilitation of primed different pairs and recombined different pairs in Experiment 7, we would expect greater facilitation, and not less as an episodic account predicts, of these items as the ratio of repeated to non-repeated items is reduced.

In Experiment 8, the proportion of stimuli that were repeated in some form was reduced by the simple expedient of adding more filler pairs to an experiment otherwise identical to Experiment 7.

Experiment 8

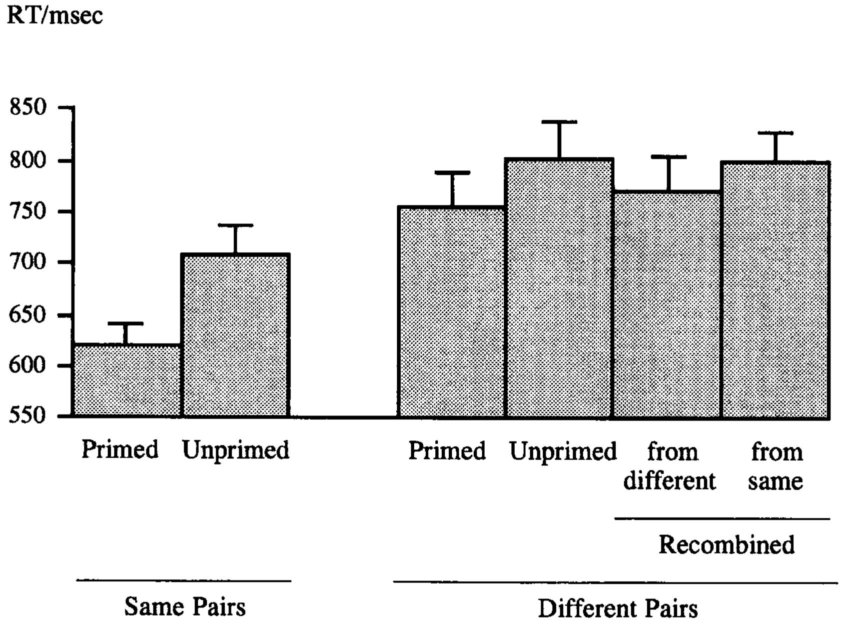
METHOD

Experiment 8 differed from Experiment 7 only in the addition of a number of filler pairs to both the training phase and the test phase. Ten same filler pairs and 10 different filler pairs were added to the training phase and 35 same filler pairs and 35 different filler pairs to the test phase. This reduced the percentage of pairs from the training phase that were repeated (in some form) from 75% to 60%. The percentage of pairs in the test phase that had been presented during training was reduced from 50% to 29.4%. The training phase in Experiment 8 lasted approximately four minutes (as opposed to three in Experiment 7); the test phase lasted approximately ten minutes (as opposed to four). All stimuli were presented in a random order within each phase.

RESULTS

Figure 4.3 shows the mean correct response latency in milliseconds to each type of picture-name pair presented in the test phase of Experiment 8. Appendix 8 includes the standard deviations associated with these means, the percentage of response latencies over 2000 msec and the mean percent error rate to each item type. Latencies over 2000 msec (0.52% of responses) and latencies of incorrect responses (2.41% of remaining responses) were excluded from the mean response latencies. Analysis of the arc-sine transformed proportions of response latencies over 2000 msec revealed no significant difference between the primed same pairs and the unprimed same pairs (p>.1), or between the three types of different pair (p>.1). There was no significant difference in the error rates for primed same pairs and unprimed same pairs (p>.1), and no significant differences in rates of errors made to the three types of different pair (p>.1).

Figure 4.3. *Experiment 8. Mean Test Phase Correct Response Latencies (in Milliseconds).* Bars indicate the standard errors of the means.



Separate one factor within-subjects (F_1) and within-items (F_2) analyses of variance (ANOVAs) were carried out on the response latencies to same pairs and to different pairs. For same pairs, there was a significant effect of priming the items, $F_1(1,15)=34.190$, $p<.0001$; $F_2(1,19)=21.803$, $p<.001$, with primed same pairs being responded to more quickly than unprimed same pairs. For different pairs, there was no significant effect of item type, $F_1(3,45)=2.074$, $p>.1$; $F_2(3,117)=1.184$, $p>.1$.

DISCUSSION

The results of Experiment 8 are consistent with the hypothesis that responses made in the test phase of Experiment 7 were based, at least in part, on subjects' explicit memory for the response associated with each stimulus at training. The addition of further filler pairs in Experiment 8 was expected to reduce the salience of the repetition of stimuli, and thus reduce the influence of explicit memory as a basis for responding. In support of this view, while in Experiment 7 there was inhibition of responses made to the recombined-from-same pairs (latencies to these stimuli were significantly slower than latencies to unprimed items), there was no such inhibition evident in Experiment 8. Significant facilitation in the processing of primed different pairs and recombined-from-different pairs, however, was not observed in Experiment 8, as it had not been in Experiment 7.

There was a 46 millisecond difference between the mean response latencies to unprimed different pairs in the two experiments, which makes comparison of the absolute latencies of responses to the repeated stimuli difficult. Priming effects were therefore calculated in two ways: as differences between the mean latency to each of the three types of repeated item and the unprimed different pairs, and this difference as a percentage of mean unprimed response latency. Values for these mean priming effects (referred to as "difference" and "proportion" respectively) are given in Table 4.2. It can be seen that all of the changes between Experiments 7 and 8 are in the direction predicted by the explicit memory hypothesis. Adding more filler stimuli to the experiment increased the facilitation in processing of primed different pairs and recombined-from-different pairs, while the inhibition of responding to the recombined-from-same pairs was reduced. Planned comparisons revealed this latter change to be statistically significant in both measures of priming [$F(2,29)=3.953$, $p<.05$, difference; $F(2,29)=4.955$, $p<.05$, proportion]. None of the other changes between the two experiments was statistically significant.

Table 4.2. *Priming Effects in Experiments 7 and 8.*

	Priming (difference)/msec			Priming (proportion)/%		
	Primed different	Recombined-from-different	Recombined-from-same	Primed different	Recombined-from-different	Recombined-from-same
Experiment 7	36.7	4.7	-50.9	5.1	0.6	-6.3
Experiment 8	46.5	31.1	1.8	6.2	4.0	0.2
			*			*

* $p<.05$

While the results of Experiment 8 are consistent with a reduction of the influence of explicit memory as a basis for responding due to the addition of filler items, these results do not reflect subjects' responding in the *absence* of such an influence. There is no prescription for interpreting the pattern of results observed in Experiment 8 alone. Although the changes between Experiment 7 and Experiment 8 are modest, it is assumed that adding even more filler items would result in larger changes. Indeed, they could be added *ad infinitum.* Therefore, the lack of a statistically significant effect of adding fillers with regard to the primed different pairs and the recombined-from-different pairs is perhaps not unexpected given the relatively small number of filler items added (a number constrained by the availability of stimulus materials).

Although the pattern of responding to the recombined-from-same pairs was not as predicted, it has been demonstrated that responding to these stimuli was most likely influenced by a factor other than automatic priming effects. The results provide no support for an account of the priming effect based solely on the retrieval of prior processing episodes; Jacoby's (1983b) finding that decreasing the proportion of items repeated from training at test decreased the amount of priming observed is not consistent with the (modest) changes between Experiments 7 and 8. Note also that Challis and Roediger (1993) were unable to replicate Jacoby's result, using a word fragment completion task rather than a perceptual identification task. The findings of Experiments 7 and 8 are, on the other hand, consistent with the evidence for an item-specific locus of repetition priming provided by Experiments 1, 2, 3, 4, 5 and 6.

5

WHEN CONTEXT AFFECTS THE IDENTITY OF A STIMULUS: REPETITION PRIMING OF HOMOGRAPHS

INTRODUCTION

On the basis of the experiments described in Chapters 2 and 3, it was argued that the locus of the priming effect in the speeded same/different matching task is a system of pre-semantic, item-specific representations. In Experiments 1, 2, 3 and 6, the context in which each stimulus item appeared - its particular partner - had no influence on the amount of benefit in responding occurring as a result of that item being repeated; there was no attenuation of priming as a result of recombining the pairings of items between training and test phases. As the memory representations underlying the priming effect were described as being those required for the identification of stimuli, this result begs a question, namely the effects of context upon repetition priming where this context affects the identity of an item. This question is addressed in this chapter.

Homographs are words which share their written form but not their meaning. For example, the written form BAT can refer to a winged mammal or to a sportsperson's implement. The particular interpretation, that is, the identity, of such a word will therefore be strongly influenced by the context in which it occurs, although one meaning of the written form may have a higher frequency of occurrence than another. Light and Carter-Sobell (1970) demonstrated that changing the interpretations demanded of homographs between study and test, achieved by changing accompanying words related to either one meaning or the other of each homograph, affected one kind of memory phenomenon, namely performance on a recognition memory test. Target homographs were first read in sentences, in which the interpretation of the word was biased in one direction by the presence of another word (*raspberry* JAM). Recognition of targets was poorer if they were accompanied by a different word at test that changed the interpretation of the target (*traffic* JAM), than if accompanied by an alternative different word that preserved the interpretation of the target (*strawberry* JAM). Episodic accounts and item-specific representation accounts make different predictions about whether this variable should affect the memory phenomenon of repetition priming.

An account based on the retrieval of specific prior processing episodes, or the reinstatement of prior processing demands, predicts less facilitation in the processing of homographs repeated with their semantic interpretation changed between training and test than of items repeated requiring the same interpretation. A change in the semantic interpretation of a homograph means that the processing demands at test less exactly reinstate those of training than if there is no change in interpretation; following a change in interpretation, a homograph at test will act as a less efficient retrieval cue for the training episode in which it was encountered. This is assuming that the test phase task requires that one specific interpretation of the homograph be arrived at in order for a response to be made. When repeated, responding to the item will benefit from the retrieval of the data-driven identification of the word's perceptual form, and also the conceptually-driven aspects of the training phase episode associated with accessing one particular meaning of the word. Jacoby is explicit in arguing that processing of meaning and surface form are inextricably linked "to an extent that does not allow one to easily treat the one dimension in isolation from the other." (Jacoby & Brooks, 1984; p.37).

The importance of the reinstatement of *interpretive* encoding operations, rather than processing operations performed subsequent to stimulus interpretation, has been stressed by some authors in accounting for repetition priming (e.g. Graf & Mandler, 1984; Masson &

MacLeod, 1992). In Experiments 1, 2, 3 and 6 described in this thesis, it could be argued that recombining the pairings of stimuli between training and test did not affect the initial interpretation of each item, and hence did not attenuate priming of these stimulus pairs. The experimental manipulation of the meaning demanded of homographs does affect interpretative encoding operations as defined by those authors.

The predictions of an item-specific representation account of the repetition effect differ from those of an episodic account, if the effect is thought result from the activation of representations of the perceptual structure and form of individual items, abstracted to a greater or lesser extent (Morton, 1969, 1979; Tulving & Schacter, 1990). As two homographs share the same *physical* form, they will share the same perceptual representation, regardless of the semantic interpretation subsequently demanded of them. That stimulus identification is a processing stage prior to semantic activation is a feature of many models of object recognition and word recognition (see, e.g., Ellis & Young, 1988), although it is possible that these processes overlap in time to a degree (Humphreys, Riddoch & Quinlan, 1988). Item-specific representation accounts therefore predict no attenuation of repetition priming following a change in the interpretation demanded of a homograph between training and test encounters. The identification of one interpretation of the word will activate the perceptual representation of that word (which is shared by the other interpretation), and hence will facilitate the subsequent identification of the other interpretation of the word just as much as the identification of the same interpretation.

An item-specific account of repetition priming would predict an effect of changing the interpretation demanded of a homograph, however, if the locus of the effect was thought to be a change in the connections between perceptual and semantic representations. There is evidence that changes in the connections between semantic representations and representations of spoken word forms underlie repetition priming of spoken word production

(Wheeldon & Monsell, 1992), so it would seem natural to propose that an equivalent earlier locus (links between perceptual and semantic representations) might underlie priming of item identification, as opposed to item naming. So, for example, in Burton *et al.*'s (1990) interactive activation model of face recognition, repetition priming occurs due to changes in the connections between perceptual representations ("face recognition units") and conceptual representations of that person's identity ("person identity nodes"). An effect of a change in the interpretation demanded of a homograph between training and test would be predicted, then, according to such a change-in-connections view if such a change occurs in the connection between the perceptual representation of a homograph and the representation of the semantic interpretation at which subjects finally arrive, and as determined by the context in which the word occurs. No effect of a change in the interpretation demanded of a homograph is predicted, however, if the locus of the effect is a change in the connections between a representation of the physical form of the word and semantic representations related to *all* of the word's various meanings. While these connections would not be shared by all interpretations of the homograph, they might be expected to be activated in parallel, with context affecting the interpretation of the word only after semantic information has been accessed. Consistent with this argument, Seidenberg, Tanenhaus, Leiman & Bienkowski. (1982) report experiments in which subjects access multiple meanings of homographs (as revealed in priming of the naming of semantically related words) for SOAs shorter than 200 milliseconds; initial access to both meanings of a homograph appears to occur automatically, with "top down" processes of context playing a role only after this access to multiple meanings. Of course, the relatively long lasting repetition priming effect need not reflect events which take place within the first 200 milliseconds of encountering an item.

What, then, is the state of the evidence? While a number of studies have examined the effects of manipulating the interpretation demanded of homographs on semantic priming (e.g. Schvaneveldt, Meyer & Becker, 1976; Seidenberg *et al.*, 1982), only a few studies have examined the effects of this variable on repetition priming. Their results can best be described as mixed. Masson and Freedman (1990) found that changing the interpretation of homographs between training and test reduced the facilitation in responding to repeated items in a lexical decision task. On each trial, the target homograph was preceded by a bias word; when repeated, the bias word for each target could be identical to that originally presented, different but preserving the meaning of the homograph as originally biased, or biasing the interpretation of the homograph towards a different meaning. Repetition effects were largest when a target homograph was preceded by the same cue at test as preceded it at training; there was less, but significant, priming if a different word preserving the same meaning preceded the target; there was no reliable priming if the cue word biased the target homograph towards an alternative meaning.

Micco and Masson (1991, Experiment 3) used a stem completion task to examine this same issue. Subjects were first given a number of sentences, with each homograph appearing in two sentences. The interpretation of each homograph was biased in one direction or another by the sentence context, and each homograph was associated with a target word in that sentence (*The man's dilated* PUPIL *resulted from seeing the dentist's* DRILL; *The elementary school* PUPIL *hates the school bus* DRIVER). The two target words shared the same first three letters. The effect of the interpretation of the homograph on repetition priming was revealed by cueing the target word-stem with its associated homograph, and by biasing the interpretation of that homograph with a related word (*eye*-PUPIL-DRI---). Targets studied with the interpretation of the homograph reinstated at test were more likely to be given as completions than targets studied with the alternative interpretation of the homograph. These results were taken as support for an episodic account of the priming effect.

Results favouring an item-specific account have also been observed. Valentine *et al.* (1993) examined transfer of repetition effects between words that can be both common nouns and surnames (e.g. the metal STEEL and the politician David STEEL). Such words were responded to in either a familiarity decision task to surnames, along with other famous and non famous surnames, or in a lexical decision task, along with other common nouns. Just as much facilitation of familiarity decisions to names was found at test if primed items had been responded to at training in the lexical decision task as common nouns, as when they had been responded to in a familiarity decision task as names. Similarly, just as much priming occurred to words in the lexical decision task at test if they were repeated from a familiarity decision task to proper names at training, as when they were repeated from an identical lexical decision task. There was no effect of changing the task between training and test, a manipulation that also changed the interpretive context of items between training and test (from common nouns to surnames and vice versa). This result is consistent with an item-specific representation account of the priming effect, phrased in terms of the activation of perceptual representations, or changes in the connections between such representation and both possible interpretations (proper name and common noun) of each item.

Masson and MacLeod (1992, Experiment 5) found just as much facilitation in perceptual identification of homographs regardless of which meaning they were biased towards by sentence contexts at training. It must be noted that a second variable was manipulated in this experiment, namely whether target words were read or generated from word fragment cues at training. There was no effect of this manipulation upon the amount of priming observed. This result - at odds with the evidence from the biasing of homographs - was taken as support for the reinstatement of interpretive encoding processes underlying the priming effect. It is also possible, however, that the word fragments and read words at training activated the same item-specific representations, an interpretation of the data consistent with the evidence from the biasing of the homographs within the same experiment.

Experiment 9 investigated the effects of manipulating the interpretation demanded of homographs, between training and test, on priming in the speeded same/different matching task; a task upon which we have already seen no effect of manipulating the pairings of items. The experiment had three phases. In the first phase (training), subjects made related/unrelated responses to pairs of words. In related pairs, one of these words was a homograph, the other word biased the meaning of the homograph towards one particular interpretation (e.g. CAVE-BAT). In the second phase (priming test), these biased homographs were then repeated paired with a picture, in a speeded same/different matching task. The picture depicted either the same interpretation of the homograph as had been biased at training (a winged mammal), or an alternative interpretation of the homograph (a baseball bat). Therefore, both primed-preserved-interpretation stimulus pairs and primed-changed-interpretation stimulus pairs contained a word that had been seen during training and a picture that had not. There were also stimulus pairs requiring a different response in the priming test phase.

The third phase of Experiment 9 was a recognition memory test. Target items consisted of homographs paired with the related words that had accompanied them in the training phase. Distractor items consisted of homographs shown at training, along with words related to an alternative interpretation of the homographs. These related words had also been presented during training, but paired with other items. The inclusion of a recognition memory test followed the same reasoning that motivated Experiment 4 in this thesis. While a finding of no effect of a change in the interpretation required of a homograph in the priming test would support an item-specific representation account and not an episodic account, it could also arise if the bias words at training did not sufficiently manipulate the interpretation of the homographs, or if the interpretation of the homographs was not sufficiently well encoded to be available to subjects in the priming test phase. If subjects were, however, able to recognise homographs *and* the particular training bias words that had accompanied them, then these latter explanations can be ruled out. Such a result would reflect, rather, different properties of the memory representations underlying performance on the priming task and the memory representations underlying performance on the recognition memory task.

Experiment 9

METHOD

Subjects. There were 16 subjects, all members of the MRC Applied Psychology Unit subject panel, mean age 21.6 years (sd=2.5). All had normal or corrected-to-normal vision and had English as their first language.

Materials. Sixty homographs were selected from The Concise Oxford Dictionary of Current English (6th Edition; Sykes, 1976). Each word met the following criteria: it has two or more main dictionary entries, at least two of these entries are unrelated in meaning, are pronounced identically and are in common usage. The 60 homographs were divided into 6 sets of 10 items, matched for a rating of word frequency (Kucera & Francis, 1967) and word length (number of letters). Appendix 9 contains the means and standard deviations of these ratings for each of the 6 sets of 10 items.

Two *bias words* were generated for each homograph word in 4 of the matched sets. For each homograph, one bias word was semantically or associatively related to one interpretation of the word; the other bias word was related to the alternative interpretation of the word (or one of the alternative interpretations, where the homograph had more than two meanings). For example, the bias words CAVE and SPORT were generated for the homograph BAT. The terms "the first" and "the second" are used to describe the two bias words; these terms do not relate to the frequency with which the alternative interpretations of each homograph occur in common usage. For each of the 80 bias words, a semantically or associatively related word was generated. For example, the bias word CAVE had the related partner POTHOLE, and the bias word SPORT had the related partner REFEREE. These materials are shown in Appendix 10.

Of the 80 interpretations of the 40 homographs in these sets, 72 were concrete nouns and 8 were easily depictable verbs (e.g. RING, BARK). For each of these 40 homographs, there were two pictures. The pictures were black and white line drawings taken from Snodgrass and Vanderwart (1980, Appendix A), the Encyclopaedia Britannica (Yust, 1951), or were purpose drawn. For each homograph, one picture depicted the homograph in the interpretation consistent with the first bias word, the other picture depicted the homograph in the interpretation consistent with the second bias word.

The homographs in the remaining 2 sets of 10 were paired with unrelated words. These words were from two of the matched sets taken from Snodgrass and Vanderwart (1980), shown in Appendix 1. Each of these homographs was also paired with a picture of a different unrelated object (Snodgrass & Vanderwart, 1980, Appendix A) from two of the other matched sets shown in Appendix 1.

Design. The design of Experiment 9 is summarised in Table 5.1. In this table, a single example substitutes for each set of 10 stimulus pairs and filler items are not included.

The experiment consisted of three phases: a training phase, a priming test phase, and a recognition memory test phase. All subjects completed the training phase first. Half of the subjects then completed the priming test phase followed by the recognition memory test phase and half completed the recognition memory test phase followed by the priming test phase.

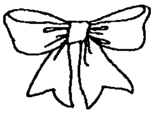
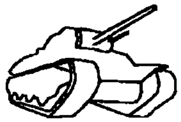
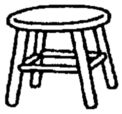
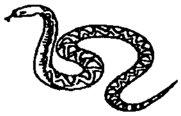
The training phase and the priming test phase were presented to subjects as separate tasks; subjects were not told of any relation between the two. The three phases were separated only by instructions to subjects.

Training phase. Subjects were presented with pairs of simultaneously displayed words. The homographs in three of the matched sets were presented along with their first bias word. The homographs in one of the remaining sets were presented along with an unrelated word. For the homographs presented with their first bias word, the second bias words were also presented in the training phase, but accompanied by their semantically or associatively related partner words. This was done so that the recognition test phase of the experiment could examine memory for the specific pairings of items, not memory for the items themselves.

There were 50 unrelated filler pairs in the training phase, comprising two semantically and associatively unrelated words, one being a homograph, the other taken from Snodgrass and Vanderwart (1980).

Subjects responded to each stimulus pair by pressing one of two alternative computer keys to indicate whether the two words were related in meaning or were unrelated. Thus, in the training phase, an equal number of "related" and "unrelated" responses were required.

Table 5.1. *Summary Experimental Design for Experiment 9.*

	Phase		
	Training (related/unrelated decision)	Priming test (same/different matching)	Recognition memory test (were the words paired at training with each other?)
1	**bat-cave**	 **bat** Primed-preserved-interpretation	
2	**bow-arrow**	 **bow** Primed-changed-interpretation	
3	**-----**	 **tank** Unprimed same pair	
4	**prune-guitar**	 **prune** Primed-different pair	
5	**-----**	 **calf** Unprimed different pair	
6	**palm-wrist**		**palm-wrist** Target item
7	**shell-coconut**		**palm-coconut** Distractor item

Priming test phase. Subjects were presented with simultaneously displayed picture-word pairs. One set of 10 homographs that were presented in the training phase along with their first bias words were repeated, each paired with a line drawing of that object that preserved the same interpretation of the word. (For example, the homograph BAT, paired with the bias word CAVE at training, was paired with a picture of a winged mammal in the priming test phase. Row 1 in Table 5.1.) These stimuli are referred to as *primed-preserved-interpretation* pairs.

One set of 10 homographs, presented in the training phase with each homograph paired with its first bias word, was repeated in the priming test, each homograph paired with a line drawing that changed the interpretation of the word. (For example, the homograph BOW, paired with the bias word ARROW at training, was paired with a picture of a knotted ribbon in the priming test. Row 2 in Table 5.1.) These stimuli are referred to as *primed-changed-interpretation* pairs.

In the priming test phase, a further set of 10 homographs were presented along with line drawings depicting one interpretation of each item. These homographs had not been seen in the training phase, and are referred to as *unprimed same* pairs (Row 3 in Table 5.1).

The 10 homographs presented in the training phase along with unrelated words were repeated in the test phase, paired with unrelated object pictures. These items are referred to as the *primed different* pairs (Row 4 in Table 5.1).

The final set of 10 homographs, not presented in the training phase, were presented in the priming test phase along with unrelated object pictures. These stimuli are referred to as the *unprimed different* pairs (Row 5 in Table 5.1).

In the priming test phase, there were also a number of filler items. Thirty same filler pairs contained an object picture taken from Snodgrass and Vanderwart (1980, Appendix A) and its appropriate object name. Thirty different filler pairs contained Snodgrass and Vanderwart (1980, Appendix A) pictures accompanied by unrelated object names. Ten object names from the set of different filler pairs presented in the training phase were also repeated in the priming test phase, accompanied by Snodgrass and Vanderwart (1980, Appendix A) pictures of unrelated objects.

In the priming test phase, subjects responded by pressing one of two alternative computer keys to indicate whether the item depicted and the word in a pair referred to the same object or to different objects. Thus, subjects made an equal number of "same" responses and "different" responses overall, and an equal number of "same" responses and "different" responses were required to items repeated from the training phase.

Recognition memory test phase. The remaining matched set of 10 homographs that had been presented in the training phase and not in the priming test was re-presented in the recognition memory test phase. Each homograph was presented with the bias word which accompanied it at training. These represent the *target* pairs (Row 6 in Table 5.1). The homographs from this set were also presented along with their second bias words to give *distractor* pairs. The second bias words had been presented in the training phase, each paired with a semantically or associatively related word and not with the homographs (Row 7 in Table 5.1). Subjects were required to indicate, by pressing one of two alternative computer keys, whether the items comprising each stimulus pair had been presented together in the training phase, or whether they had not been presented together in the training phase. As both of the items comprising each stimulus pair had been presented during the training phase, this final phase of Experiment 9 therefore represents a recognition memory test for the *pairings* of items presented in the training phase.

Materials were rotated between sets across subjects. Stimulus pairs were rotated between the primed-preserved-interpretation pairs, the primed-changed-interpretation pairs and the unprimed-same pairs occurring in the priming test phase of the experiment, and the target items appearing in the recognition memory test phase. These items were also rotated with respect to which bias word first accompanied the homographs in the training phase. Stimuli were rotated between the two sets of pairs requiring a "different" response in the priming test phase.

Procedure. Each subject was tested individually, viewing a computer monitor at a distance of approximately 50 cm.

In the training phase, subjects were presented with stimulus pairs comprising two words on the monitor. The words were presented one above the other, in lower case bold helvetica font, subtending a visual angle of 1.7° vertically, mean 4.0°, range 3.4-6.0°, horizontally. The two words were separated by a visual angle of 2.3°. For the stimulus pairs which included a homograph, in half the stimulus pairs the homograph was presented above the other word, in half the cases below. The training phase began with four practice trials in which filler pairs were presented. Stimuli were subsequently presented in a random order within the training phase. All subjects responded with the right index finger on key "M" to indicate a "related" match and with the left index finger on key "Z" to indicate an "unrelated" match. Following a response, the screen was cleared and the next pair of words presented after an interval of 1500 msec. Instructions stressed that responses should be made as quickly as possible, but not at the expense of accuracy. The training phase lasted approximately five minutes.

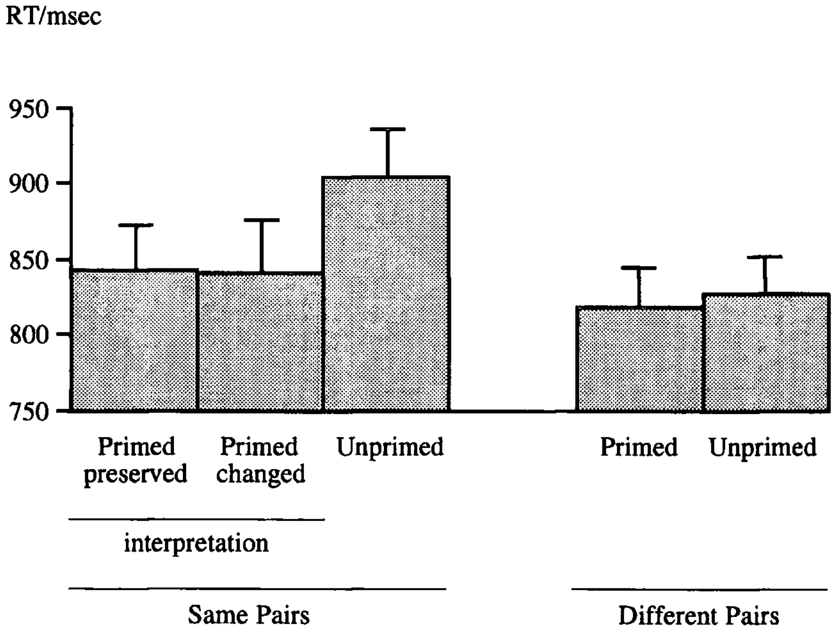
The priming test phase of the experiment began with instructions which lasted approximately three minutes. In the priming test itself, stimulus pairs comprising a line drawing of an object (scaled to subtend a visual angle of 6.3° vertically; mean 6.9°, range 2.3-10.9° horizontally) and a word (lower case, bold helvetica font, subtending a visual angle of 1.7° vertically; mean 4.0°, range 3.4-6.0°, horizontally) were presented. The picture was presented simultaneously with and directly above the word (separated by a visual angle of 1.1°). The priming test phase began with four practice trials in which filler pairs were presented. Stimuli were subsequently presented in a random order within the priming test phase. All subjects responded with the right index finger on key "M" to indicate a "same" match and with the left index finger on key "Z" to indicate a "different" match. Following a response, the screen was cleared and the next picture-word pair presented after an interval of 1500 msec. Instructions stressed that responses should be made as quickly as possible, but not at the expense of accuracy. The priming test phase lasted approximately five minutes.

The recognition memory test phase was preceded by instructions which lasted approximately two minutes. In the test, stimuli were pairs of words, presented as in the training phase of the experiment. Subjects responded with the right hand on key "M" to indicate that the two words comprising a stimulus pair had been presented together in the training phase of the experiment. They responded with the left hand on key "Z" to indicate that the words comprising a stimulus pair had not been presented with each other at training. Following a response, the screen was cleared and the next pair of pictures presented after an interval of 1500 msec. Instructions for the recognition memory test stressed that there was no time constraint upon responding and that responses should be made as accurately as possible. Subjects were told that both items comprising each stimulus pair had been presented in the first phase of the experiment and that they should respond on the basis of their memory for the pairings of items. They were instructed to guess if unable to respond with confidence on any trial.

RESULTS

Priming test. The measure of interest in the priming test phase of Experiment 9 was the latency of correct responses made to the different types of picture-name pairs. Figure 5.1 shows the mean correct response latency in milliseconds to each item type. Appendix 11 includes the standard deviations associated with these means, the percentage of response latencies over 2000 msec and the mean percent error rate to each item type. Latencies over 2000 msec (1.38% of responses) and latencies of incorrect responses (6.25% of remaining responses) were excluded from the mean response latencies.

Figure 5.1. *Experiment 9. Mean Test Phase Correct Response Latencies (in Milliseconds).* Bars indicate the standard errors of the means.



Analysis of the arc-sine transformed proportions of response latencies over 2000 msec revealed no significant difference between the three types of stimulus pair requiring a "same" response in the priming test, i.e. the primed-preserved-interpretation, primed-changed-interpretation and unprimed same pairs (p>.1). There were no responses made with latencies over 2000 msec to either the primed or unprimed different pairs. Analysis of arc-sine transformed proportion error rates revealed no differences between the three types of same pair ($p>.1$), or between the primed and unprimed different pairs ($p>.1$). There was no apparent speed-accuracy trade-off in subjects' responding.

One subject was excluded from these analyses, having made 14% of responses with latencies over 2000 msec. (The mean percentage of responses with latencies over 2000 msec, including this subject's replacement, was 1.38; the standard deviation was 4.11.)

Separate analyses of variance were performed on response latencies to same pairs and to different pairs. Analyses by-subjects are denoted by the subscript $_1$ and analyses by-items by the subscript $_2$. For same pairs, an ANOVA was performed with item-type (primed-preserved-interpretation, primed-changed-interpretation and unprimed same pairs) as a within-subjects and within-items factor, and order of test presentation (priming test before recognition memory test and vice versa) as a between-subjects and within-items factor. The analysis by-items also included the within-items factor of bias (i.e. the particular interpretation demanded of each homograph in the priming test phase. This factor therefore had 2 levels: first interpretation and second interpretation).

There was a significant effect of item-type, $F_1(2,28)=4.678$, $p<.05$; $F_2(2,414)=3.467$, $p<.05$. Post hoc Newman-Keuls tests revealed response latencies to the primed-preserved-interpretation pairs to be significantly faster than to the unprimed same pairs ($p_1<.05$; $p_2<.05$). Latencies of responses to the primed-different-interpretation pairs were also significantly faster than to the unprimed same pairs ($p_1<.05$; $p_2<.05$). There was no significant difference in response latencies made to the primed-same-interpretation and the primed-different-interpretation pairs ($p_1>.1$; $p_2>.1$). Therefore, changing the interpretation required of a homograph between study and test had no effect upon the degree to which responding was facilitated by repetition. There was no effect in the analysis by-subjects of whether the priming test had been performed before or after the recognition memory test [$F_1(1,14)=1.920$, $p>.1$]. In the analysis by-items, however, this effect was significant, $F_2(1,414)=10.194$, $p<.01$; responses were made more quickly when the priming test was performed before the recognition memory test. In neither analysis did order of test presentation interact with item-type [$F_1<1$; $F_2<1$]. In the analysis by-items, there was no effect of the particular interpretation towards which each homograph was initially biased [$F_2(1,414)=1.941$, $p_2>.1$]. This factor did not interact with item-type [$F_2<1$] or order of test presentation [$F_2<1$]. There was no significant three-way interaction [$F_2(2,414)=2.823$, $.1>p>.05$].

There was no significant effect of priming the stimulus pairs requiring a "different" response, in either the analysis by-subjects [$F_1<1$], or by-items [$F_2<1$]. This result does not affect the interpretation of the pattern of response latencies made to the same pairs, which is the principal focus of interest in this experiment. There was no effect of whether subjects performed the priming test before or after the recognition memory test in the analysis by-subjects [$F_1(1,14)=2.597$, $p>.1$]. This effect was significant in the analysis by-items, $F_2(1,19)=5.295$, $p_2<.05$; response latencies being made more quickly when the priming test was performed before the recognition memory test. The interaction between item-type and order of test presentation did not reach statistical significance in either analysis [$F_1(1,14)=3.651$, $.1>p_1>.05$; $F_2(1,19)=1.221$, $p>.1$].

Recognition memory test. The mean number of correct recognition responses to target pairs (hits) was 9.25 out of a possible maximum of 10 (sd=0.58). The mean number of correct rejections of distractor pairs was 8.19 out of 10 (sd=1.17). Single sample t-tests revealed a measure of accuracy (hits-false alarms) to be well above chance level ($t_1=23.550$, df=15, $p<.0001$; $t_2=19.035$, df=79, $p<.0001$). This measure did not differ significantly whether the recognition memory test was performed before or after the priming test (t_1=0.989, df=15, p>.1; t_2=0.779, df=79, p>.1). Full signal detection analyses were not performed on these data as hits and false alarms were not truly independent. Both target and distractor pairs contained one item (the homograph) in common; thus responding in one way to the first occurrence of a pair containing a particular homograph may have biased responding on the second occurrence.

DISCUSSION

In Experiment 9, significant facilitation in the processing of picture-word pairs requiring a "same" response was observed in the priming test phase, where the word had been repeated from the training phase. Importantly, there was just as much priming of stimulus pairs containing a homograph whose meaning was changed between training and test, and of pairs containing a homograph that retained its meaning between training and test; i.e. latencies to primed-changed-interpretation pairs and primed-preserved-interpretation pairs did not differ significantly. This result was evident in both analysis by-subjects and by-items, and held regardless of the interpretation towards which the homographs were initially biased. Under the same encoding conditions, subjects were able to recognise which bias word had been paired with each homograph at training, at well above chance levels. An unexpected finding was the lack of a repetition priming effect for the pairs requiring a "different" response in the test phase. The primed different pairs were responded to more quickly than the unprimed different pairs, but this difference did not reach statistical significance. In the other experiments using a speeded same/different matching task in this thesis (Experiments 1, 2, 3, 5, 6, 7 and 8), smaller priming effects for different pairs than for same pairs have consistently been found. In those experiments both of the stimuli comprising a stimulus pair were repeated from training at test; in Experiment 9 here only the word was repeated from training. These two facts together suggest a reason for the absence of a reliable priming effect for the different pairs in Experiment 9. This result does not affect the interpretation of the pattern of response latencies made to the same pairs, which is the principal focus of interest in this experiment.

These results provide no evidence of any role for the retrieval of prior processing episodes in performance on the repetition priming test. An episodic account would predict less priming of homographs following a change in interpretation between training and test than of homographs repeated with the interpretation demanded of them preserved. When the changed-interpretation items are repeated at test, they would act as a less efficient retrieval cue for the training encounter with that homograph; responding in the test phase cannot benefit from the retrieval or reinstatement of the interpretation of the homograph that was established in the training phase. The other stimulus presented simultaneously with each homograph in Experiment 9 can be described as providing the interactive context in which the homograph occurred. Interactive contexts affect the interpretation of an item in some way, and can be contrasted with independent contexts, which do not (Baddeley, 1982). The reinstatement of interactive context, or interpretative encoding mechanisms, has been proposed by some authors to underlie the repetition priming effect, rather than the reinstatement of independent context or elaborative processing performed subsequent to stimulus identification (Graf & Mandler, 1984; Masson & MacLeod, 1992; Micco & Masson, 1991). The results of Experiment 9 are not consistent with this position. These results also pose problems for an item-specific account of repetition priming in which the locus of the effect is a change in the strength of the connection between a perceptual representation of the word and the semantic representation of the interpretation demanded by the context in which it occurs.

The results support, however, the locus of the effect being a representation of the perceptual structure of the word. According to such an item-specific representation account, as the two (or more) interpretations of a homograph have identical physical forms, they will share a representation in the pre-semantic perceptual system dedicated to the recognition of that item. The word should, therefore, be primed just as much, regardless of the interpretation demanded of it; this is as found. Alternatively, the priming effect could reflect changes in the connections between such a perceptual representation and semantic representations of *all* possible meanings of the item (cf. Valentine *et al.*, 1993). In this case, changes in connection strength must occur before there is competition between the alternative semantic representations in order to arrive at an unambiguous interpretation of the word. Under exactly the same encoding conditions for which there was no sensitivity of the priming measure to the interpretation of homographs, subjects were able to recognise which bias words had accompanied each homograph in the training phase at well above chance levels. Therefore, the lack of sensitivity of the priming measure to the interpretation demanded of homographs cannot simply be due to the fact that this variable was not manipulated strongly enough, or that subjects had not encoded this information sufficiently well for it to be available to them in the priming test phase. Rather, this dissociation between repetition priming and recognition memory reflects the fact that information about the context-based interpretation of an item was not essential to the memory representation underlying the repetition priming effect observed.

This conclusion is supported by the fact that there was no effect on the pattern of priming observed of the order in which the priming test phase and the recognition memory test phase were performed. There was a main effect of this variable (in the analyses by-items but not by-subjects), with responses in the priming test being made more slowly if the recognition memory test had been performed first, but no interaction with the pattern of priming effects. Yet when the recognition memory test was performed first, instructions would have drawn subjects' attention to the fact that stimulus words were homographs, and that the meaning of these homographs could be changed from that initially established at training by an accompanying word. Having such knowledge, however, did not affect the pattern of performance on the priming test, thus providing further evidence that the representations underlying the repetition priming did not contain any information about the context-based interpretation of an item.

The dissociation between performance on the priming test and the recognition memory test provides a possible explanation for the apparent disparity between the results of Experiment 9 and those of Masson and Freedman (1990) and Micco and Masson (1991, Experiment 3). It is possible that in these studies, subjects were using explicit memory for the interpretation demanded of a homograph as a basis for responding in the priming test. In Masson and Freedman's (1990) study, there was an 1100 millisecond stimulus onset asynchrony (SOA) between the presentation of an interpretation-biasing cue word and the homograph target. Subjects may have been able to generate expectancies about the target's identity on the basis of this cue. In Micco and Masson's (1991) experiment, subjects were not prevented from, and may well have benefited from, using the combined bias word-homograph cues to recall the target words from training. Evidence for the role of explicit memory strategies in performance on the cued word-stem completion task was discussed in Chapter 2. In Experiment 9 reported here, explicit memory is less likely to have formed a basis for responding in the priming test due to the speeded nature of the task; indeed, the dissociation between performance on the priming test and the recognition memory test revealed explicit memory not to have been so used.

The results of Experiment 9 thus require no change in the conception of the memory representations underlying priming in the speeded same/different matching task described in Chapters 2 and 3. The representations were described as item-specific (Experiments 1, 2, 3 and 6), perceptual and not conceptual in nature (Experiment 5) and independent of the memory representations underlying recognition memory (Experiment 4). Experiment 9 provides further evidence that the representations are of perceptual and not conceptual identity; changing the meaning of a word while it retains its perceptual form does not attenuate the repetition effect, even when subjects can remember the original interpretation of the word.

The results of Experiment 9 do not address further the exact nature of the item-specific locus of the priming effect. The results could reflect the activation of a perceptual representation shared by the two words with the same physical form. This perceptual representation could be a stored representation of the item's identity or it could be a structural description created after the single training phase trial. Alternatively, such results could reflect activation of connections between this shared form and semantic representations of both meanings of the word in parallel.

The nature of the item-specific representations is more closely examined in the next chapter. Experiment 10 was performed to examine repetition priming of stimuli that have perceptual structure, but for which there are no pre-existing representations of this structure and no connections from perceptual representations to semantic information. The stimuli used were drawings of novel objects.

6

PRE-EXISTING REPRESENTATIONS AND REPETITION PRIMING: RECOMBINING PAIRS OF UNFAMILIAR OBJECTS

INTRODUCTION

As was discussed in Chapter 1, a distinction can be made within the class of item-specific representation accounts of repetition priming as to whether priming of novel or unfamiliar stimuli is predicted. Some authors argue that priming results from the activation of pre-existing memory representations of familiar items (e.g. Diamond & Rozin, 1984; Graf & Mandler, 1984; Morton, 1969, 1979). For example, in Morton's logogen model of single word recognition, the linguistic unit of each item-specific representation is, give or take an inflection, a word (Murrel & Morton, 1974). Similar stored representations of familiar objects have been described as the locus of the priming effect for visual objects (e.g. Seymour, 1973; Warren & Morton, 1982). Such accounts predict that repetition priming of novel or unfamiliar stimuli should not occur. For example, reading a nonword letter string would not result in the activation of any logogen - the string would not be recognised as a word - and hence there would be no facilitation in processing the same nonword if repeated.

As was also discussed in Chapter 1, however, there is now considerable evidence that repetition priming of certain types of both nonwords and novel objects can occur (Dorfman, 1994; Feustel *et al.*, 1983; Kroll & Potter, 1984; Kunst-Wilson & Zajonc, 1980; Musen & Treisman, 1990; Rueckl, 1990; Scarborough *et al.*, 1977; Schacter *et al.*, 1990). These results pose problems for theories of the priming effect based on the activation of pre-existing representations of known items, but are consistent with the effect resulting from the creation of *new* item-specific representations. Constraints on the generality of the priming of novel stimuli, such as Dorfman's (1994) finding that only nonwords with familiar morphemic and syllabic structure can be primed, or Schacter *et al.*'s (1990) finding that only structurally possible figures can be primed, are consistent with novel items being represented in terms of novel combinations of familiar sublexical and sub-object components.

While there is evidence that repetition priming of novel stimuli can occur, it must be noted that this does not mean that priming dependent upon the activation of pre-existing representations *does not* occur. There is a reason for at least entertaining this locus as that underlying the priming effect observed in the experiments described thus far in this thesis. The results of Experiments 1, 2 and 3 were consistent with the locus of the effect in the speeded same/different matching task being item-specific; in these experiments there was no attenuation of priming following the recombination of stimulus pairings between training and test encounters. This result also held when stimuli were drawn from within the single domain of object pictures (Experiment 6). One can ask, how is the system underlying priming able to treat the single stimulus display as comprising two independent items? Experiments 1, 2, 3 and 6 used stimuli that were highly familiar to subjects, and so one possible answer to this question is that the single display is parsed on the basis of subjects' prior knowledge of the identities of the items it contains.

Chapter 6 contains a single experiment - Experiment 10 - which examined the effect upon repetition priming of recombining pairs of novel objects between training and test. Subjects performed a speeded same/different matching task to pairs of simultaneously presented items. A subset of stimulus pairs were repeated from the training phase in the test phase, and a subset of these repeated pairs were re-paired between training and test, as they had been in Experiments 1, 2, 3 and 6.

This experiment allows us to refine the conception of the item-specific representations described as underlying the priming effects observed in earlier experiments. A first issue concerns whether repetition priming occurs at all, i.e. whether there is facilitation in the processing of stimulus pairs repeated from the training phase in the test phase of the experiment. Such straightforward repetition priming would reveal the effect to depend not upon the activation of pre-existing representations of familiar stimuli, or upon changes in the connections between perceptual representations and semantic representations, but rather upon some representation of perceptual structure and form that can be created after a single encounter with a stimulus item.

A second issue concerns the independence of the representations of the two novel objects simultaneously displayed. It is possible that with no pre-existing representations of the identities of the objects present, the system underlying priming would have no *a priori* basis for treating the single display at training as comprising two objects, resulting in the stimulus pair being represented together in memory. With pairs of novel objects, an effect of recombining pairs of stimuli between training and test, not seen in Experiments 1, 2, 3 and 6, might therefore be expected. A recombined pair at test would less readily activate this representation than a pair repeated intact, and hence there would be less facilitation in responding to recombined, as compared to intact, stimulus pairs. In such circumstances, the memory representations underlying the repetition priming effect could not be described as item-specific.

On the other hand, it is possible that the two items comprising a single stimulus display are represented independently in the memory system that underlies repetition priming. According to such an item-specific account, there should be as much facilitation in responding to recombined pairs as to pairs repeated intact, as both contain two items presented earlier and information about the specific pairings involved is not encoded in the representations underlying the effect. According to this possibility, the independent representation of the simultaneously presented items must be based on information contained within the display itself, and not result from the pre-existence of independent representations of those items.

Apart from the unfamiliarity of the object picture stimuli, Experiment 10 had the same design as Experiment 6. Stimulus pairs requiring a “same” response contained two exemplars of one novel object, differing in either an exaggeration of some features relative to others, or a plausible rotation in depth. Stimulus pairs requiring a “different” response contained two pictures of structurally different novel objects.

Experiment 10

METHOD

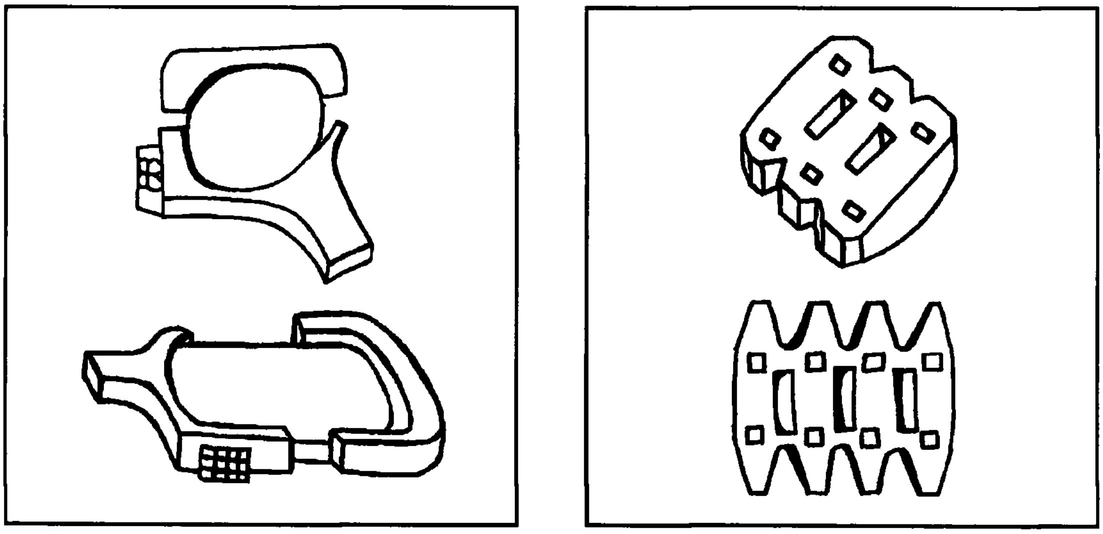
Subjects. There were 16 subjects, all members of the MRC Applied Psychology Unit subject panel, mean age 29.3 years (sd=6.6). All had normal or corrected-to-normal vision.

Materials. Materials comprised 120 line drawings of novel objects. These were closed figures with an object-like appearance that could be realised in three-dimensions. Eighty eight of them were taken from Kroll and Potter (1984, Figure A-1). A further 12 new novel objects were purpose drawn to resemble the Kroll and Potter items in style as closely as possible. Kroll and Potter (1984, Table A-1) provided a rating of each novel object’s similarity to a real object. The purpose drawn novel objects were similarly rated on a 7 point scale by 20 subjects, all postgraduate students or staff at the MRC Applied Psychology Unit.

These 100 items were divided into 10 sets, each containing 10 items, matched for the rating of similarity to real objects (see Appendix 12).

These materials were organised to produce stimulus pairs consisting of two line drawings of novel objects. There were two sets of 10 *same* pairs containing two drawings of the same object, the first taken from one of the matched sets described above, the second being purpose drawn. The second picture in a same pair represented what might be considered a "different exemplar" of the same class of object as the first item. Each second picture was based on the first novel object picture but had different features exaggerated, or represented a plausible different view of the first novel object, in much the same way that same pairs in Experiment 6 contained two different exemplars of the same familiar object. Two examples of stimulus pairs requiring a "same" response are given in Figure 6.1. There were four sets of 10 *different* pairs, containing two line drawings of different novel objects, taken from the matched sets described above. A set of filler pairs (32 same pairs and 12 different pairs) was developed from further purpose drawn pictures.

Figure 6.1. *Examples of Two Same Novel Object Picture Pairs Used in Experiment 10.* Each pair contained two plausible different views of the same object, or two exemplars of what might considered the same class of object.

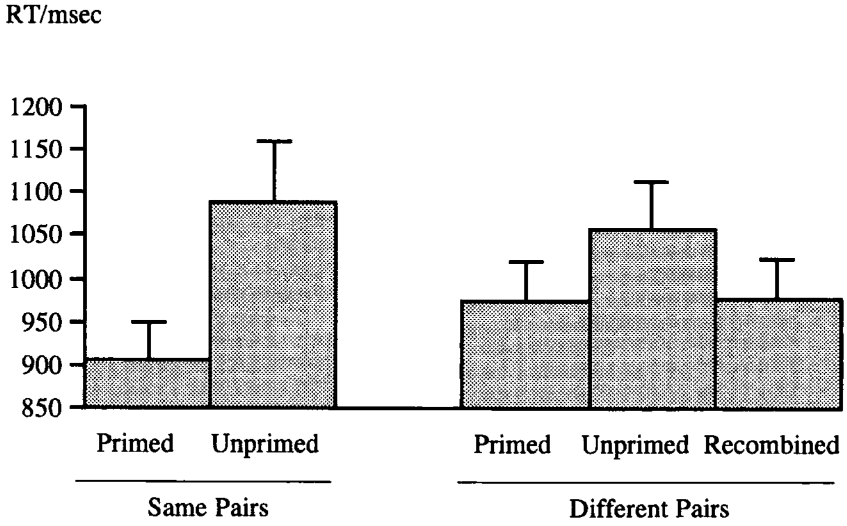


Design and Procedure. The design of Experiment 10 was identical to that of Experiment 3; details of stimulus presentation were identical to those of Experiment 6. In the instructions to subjects, it was explained that the pictures of objects in trials requiring a "same" response may differ in terms of certain surface features or the angle at which the objects are viewed. Examples of "same" matches using familiar objects were used to illustrate this distinction (a vintage car and a saloon car; a cat sitting and a cat standing), although it was stressed that all stimuli in the experiment would be unfamiliar to subjects. The training phase lasted approximately three minutes; the test phase three and a half minutes.

RESULTS

Figure 6.2 shows the mean correct response latency in milliseconds to each type of novel object picture pair presented in the test phase of Experiment 10. Appendix 13 gives the standard deviations associated with these mean response latencies, the percentage of response latencies over 2000 msec and the mean percent error rate to each item type.

Figure 6.2. *Experiment 10. Mean Test Phase Correct Response Latencies (in Milliseconds).* Bars indicate the standard errors of the means.



Latencies over 2000 msec (6.00% of responses) and latencies of incorrect responses (10.34% of remaining responses) were excluded from the mean response latencies. Analysis of the arc-sine transformed proportions of response latencies over 2000 msec revealed no difference between primed and unprimed same pairs ($p>.1$), or between the three types of different pair ($p>.1$). Analysis of arc-sine transformed proportion error rates revealed no differences between the three types of same pair ($p>.1$), or between the primed and unprimed different pairs ($p>.1$). There was no apparent speed-accuracy trade-off in subjects' responding.

Separate one factor within-subjects (subscript $_1$) and within-items (subscript $_2$) analyses of variance were carried out on response latencies to same pairs and to different pairs. For same pairs, there was a significant effect of priming the items, $F_1(1,15)=17.640$, $p<.001$; $F_2(1,19)=29.400$, $p<.0001$, with primed same pairs being responded to more quickly than unprimed same pairs.

Of main interest here is in the response to the different pairs, for which there was a significant effect of item type, $F_1(2,30)=7.606$, $p<.01$; $F_2(2,78)=3.891$, $p<.05$. Differences between individual means were examined using post hoc Newman-Keuls tests. There was a significant repetition priming effect, with primed different pairs being responded to more quickly than the unprimed different pairs ($p_1<.01$; $p_2<.05$). Recombined different pairs were responded to more quickly than the unprimed different pairs ($p_1<.01$; $p_2<.05$). There was no reliable effect of recombining the items within a pair; response latencies to the recombined different and primed different pairs did not differ significantly ($p_1>.1$; $p_2>.1$).

DISCUSSION

Experiment 10 extends the findings of Experiments 1, 2, 3 and 6. There was statistically significant facilitation in responding to pairs of novel objects repeated from the training phase in the test phase, both when "same" responses and when "different" responses were required. There was no significant effect of recombining the pairings of items between training and test: response latencies made to primed different pairs and recombined different pairs did not reliably differ. This pattern of results was revealed in both analyses by-subjects and by-items.

These results, like those of Experiments 1, 2, 3 and 6 which also used the logic of recombining the pairings of items between training and test, provide no evidence of any role of the retrieval of prior processing episodes, or the reinstatement of prior processing demands, in producing the repetition priming effect. While the two unfamiliar objects comprising a recombined different pair presented at test had been presented during the training phase of the experiment, they had not been presented together, and a response had not been made on the basis of a comparison of the two. An episodic account predicts less facilitation in responding to recombined different pairs than to primed different pairs, as only the latter exactly reinstate the processing demands of single training trials. Such a difference was not found. The results of Experiment 10 are instead compatible with an item-specific representation account of the effect. Stimuli appeared to be primed independently, regardless of their specific pairings.

As stimuli were all novel objects, the memory representations underlying the priming effect could not be stored, pre-experimental representations of known objects. Nor could the effect result from changes in the connections between perceptual representations and semantic representations (a possible locus of the priming effect discussed in the last chapter) as the stimuli were essentially meaningless This result is therefore consistent with the numerous demonstrations of the priming of novel objects (e.g. Kroll & Potter, 1984; Schacter *et al.*, 1990). While these stimuli might be represented in terms of sets of pre-existing sub-object components and the relations between such components (e.g. Biederman, 1987), the entire description would be novel to subjects. This representation is created after a single encounter with a stimulus item, and is capable of producing facilitation in the processing of that same item when repeated over delays at least as long as those evident in Experiment 10 (after an average intervention of 70 stimulus trials, or approximately 3 minutes). The representations are therefore item-specific, but they are not so by virtue of the known identity of each stimulus; they are best described as structural descriptions.

There must therefore be some perceptual process by which the single stimulus display presented in Experiment 10 came to be treated as comprising two items rather than just one, and this process cannot depend upon the pre-existence of representations of the independent identities of stimuli, as they were novel objects. Candidate processes would be the gestalt laws of perceptual grouping such as closure, collinearity, parallelism, proximity and continuation (Biederman, 1987; Koffka, 1935; Wertheimer, 1923). These grouping processes can be thought of as taking advantage of non-accidental properties of the visual array; properties that usually reflect the presence of independent objects in the real world. The visual system makes use of these grouping processes to represent each of the simultaneously presented items separately in the kind of memory that underlies repetition priming, and which is devoted to the purposes of individual item identification.

7

WHEN REINSTATING PRIOR PROCESSING DEMANDS DOES NOT PRODUCE THE LARGEST REPETITION PRIMING EFFECTS

INTRODUCTION

The activation of item-specific pre-semantic representations has provided the best account of the repetition priming effects observed in the experiments described thus far in this thesis. These representations are described as containing only information pertinent to the task of identifying individual stimuli. It has been seen that manipulating variables that are not relevant to this end do not affect the degree to which responding to repeated stimuli is facilitated. Recombining the pairings of items between an initial and a subsequent encounter does not reliably attenuate repetition priming (Experiments 1, 2, 3 and 6), even under conditions where subjects could remember the pairings of items (Experiments 2 and 4). While such novel associations (the pairings of items) do not appear to be represented in the memory system that underlies repetition priming, other kinds of novel information can be, namely information about the structure and form of individual unfamiliar items (Experiment 10). This dissociation is consistent with constraints on the occurrence of repetition priming coming from the requirements of the function subserved by the system underlying the effect. Experiment 9 provides a qualification of what is meant by the "identification" of individual stimuli. Manipulating identity in terms of meaning did not affect repetition priming; representations underlying the effect are of the perceptual structure and form of individual stimuli. Manipulating information that *is* pertinent to the task of stimuli identification, such as the representational domain in which stimuli are presented (e.g. picture or word) does affect the degree of priming observed (Experiment 5).

It follows from an item-specific representation account that there should be types of task in which repetition priming cannot be observed. If the representations underlying repetition priming are dedicated to representing stimuli for the purposes of identification, then the priming effect should only be observed in tasks which require access to these representations, that is, tasks which require that stimuli actually be identified. Performance of tasks which do not require access to the representations used in stimulus identification in order to be completed should not benefit from these representations having been activated by prior encounters with the same stimulus items. Testing this prediction is a worthwhile exercise because, as before, it is not a prediction made by a different class of theoretical accounts of repetition priming, namely those based on the retrieval of prior processing episodes or the reinstatement of prior processing demands.

According to an item-specific representation account, there should be priming of an item at test as long as the representation of that item's identity has been activated - i.e. it has been recognised - in some earlier training phase. Priming is predicted regardless of whether the training phase task and the test phase task are the same or are different. According to an episodic account, though, performing different tasks at training and test will produce less repetition priming than performing the same task in each phase of the experiment, because processing demands are not exactly reinstated in the first case. An item-specific representation account also predicts that there should be no facilitation in the processing of a repeated item when the task at test does not require access to representations of the identities of individual items. In contrast, episodic accounts predict facilitation in the processing of an item simply to the extent that prior processing demands are reinstated at test.

The series of experiments performed by Ellis *et al.* (1990) illustrate these different predictions of the two classes of account of repetition priming. The stimuli used in Ellis *et al.*'s (1990) study were photographs of famous and non-famous faces, with subjects making either familiarity decisions (familiar or unfamiliar), sex decisions (male or female), or expression decisions (smiling or unsmiling) to each item. To make familiarity decisions requires access to representations of the identity of each face, whereas decisions about the sex of a depicted person or their expression do not require access to such representations. This distinction is a feature of Bruce and Young's (1986) functional model of face processing and is supported by double dissociations between impaired and preserved ability to recognise familiar faces and recognise facial expressions that can occur as a result of brain injury (Young, Newcombe, de Haan, Small & Hay, 1993).

Ellis *et al.* (1990) found no priming, in normal subjects, of sex decisions and expression decisions made at test to repeated items. This lack of repetition priming held both following the same sex decision or expression decision task at training, or following familiarity decisions at training. In contrast, there was priming of familiarity decisions made at test to repeated items. Ellis *et al.*'s (1990) results are consistent with access to representations of the identity of each face being necessary for repetition priming to be observed, and not just the reinstatement of prior processing demands. An episodic account predicts that there should have been priming of sex decisions at test following sex decisions at training, and priming of expression decisions at test following expression decisions at training, as in these cases training processing demands are exactly reinstated at test. This was not observed. Ellis *et al.* (1990) also found that familiarity decisions made to repeated items were primed just as much by sex- or expression decisions made at the first encounter with those items as by familiarity decisions. It was argued that this occurred because at the first, training, encounter with each face, it was recognised automatically, i.e. the representation of that item's identity was activated. Access to this activated representation was then required to perform the familiarity decision task at test. An episodic account, however, predicts less priming of familiarity decisions at test following sex- or expression decisions during training than following familiarity decisions during training; in the former cases the exact same processing demands from training are not reinstated at test, while in the latter case they are. Again, such a pattern of results was not observed. The combinations of training phase task and test phase task in which repetition priming occurred in the Ellis *et al.* (1990) study are, therefore, consistent with the priming effect resulting from activation of item-specific representations in a system dedicated to the initial recognition of stimuli, and are not consistent with an account based solely on the reinstatement of prior processing demands, or the retrieval of prior processing episodes.

Experiment 11 further investigated the conditions under which the repetition priming effect is observed, in terms of the basis upon which responses were required and the combinations of training and test phase task. Stimuli were pairs of simultaneously presented line drawings of objects, with each drawing having a small section coloured. The colour of each section, and its location within the line drawing, were not related to the identity of the object. Subjects made same/different decisions to these stimulus pairs on the basis of different attributes. Matching on the basis of the identity of the two items in a pair (are they examples of the same thing or different things?) required access to the item-specific representations of those items used in object recognition. In contrast, same/different matching of the coloured sections of the two items comprising a pair was a task deemed not to require access to representations of the individual items' identities. The colours used and their locations were arbitrary, and there is in any case a literature suggesting that colour information about an object is represented separately from information about the structure and form of that object. This literature includes experimental studies of object recognition (e.g. Ostergaard & Davidoff, 1985), neurophysiological studies of cell responses (e.g. Desimone, Schein, Moran & Ungerleider, 1985), and reports of dissociations in patients following neurological insult (e.g. Meadows, 1974). There are therefore *a priori* reasons for expecting decisions about colour attributes of an object to not require access to representations of that item's identity. Such representations, however, might concurrently be activated in the colour matching task if recognition of an object is a mandatory process, that is, if a familiar object cannot be seen without being recognised (cf. Ellis *et al.*, 1990; Fodor, 1983).

Experiment 11 had a basic design common to most repetition priming experiments. There were two phases, a training phase and a test phase, with a subset of stimulus pairs from the training phase being repeated in the test phase. Repetition priming was measured in terms of faster test phase responding to these repeated pairs than to pairs seen for the first time at test. There were three between-subjects experimental conditions. Subjects either performed the identity matching task in both phases of the experiment (identity-identity matching), or they performed the colour matching task in both phases (colour-colour matching), or they performed the colour matching task in the training phase and the identity matching task in the test phase of the experiment (colour-identity matching).

Under these conditions, the predictions of the item-specific representation accounts and the episodic accounts of repetition priming are different. According to the former, there should be equivalent priming in the identity-identity matching and the colour-identity matching conditions. The matching on the basis of the stimulus items' identities at test requires access to item-specific representations of the objects in question, and both the identity matching task and the colour matching task at training will result in automatic activation of these representations. There should be no repetition priming in the colour-colour matching condition, as this task does not require access to item-specific representations. According to an episodic account, there should be *more* priming in the identity-identity matching condition than in the colour-identity matching condition, as the former condition involves an exact reinstatement of prior processing demands at test - the same stimuli and the same task to be performed - while the latter involves a change in processing demands between training and test - the same stimuli but a different task to be performed.

According to an episodic account, there should also be priming evident in the colour-colour matching condition, as, again, processing demands overlap completely the first and the second time a stimulus pair is encountered. A proviso in this case is that it is desirable that response latencies in the colour matching task should be comparable to, or longer than, those of the identity matching task. In the Ellis *et al.* (1990) study, while priming was observed for familiarity decisions but not sex decisions at test, latencies of sex decisions were also considerably faster (e.g. for responses to unprimed familiar faces, some 553 msec for sex decisions as opposed to 744 msec for familiarity decisions, in Experiment 3). Similarly, while no priming of expression decisions was observed at test by Ellis *et al.* (1990), latencies of expression decisions were faster than those of familiarity decisions (for responses to unprimed familiar faces, some 664 msec for expression decisions as opposed to 827 msec for familiarity decisions, in Experiment 2). It thus remains possible that repetition priming effects only occur, or are only detectable, in tasks that take longer to perform. However, Ellis *et al.* (Experiment 4) found that a significant priming effect in the familiarity decision task was still observed when they reduced response times of familiarity decisions to a level comparable with that of sex- and expression decisions by reducing exposure durations of stimuli and encouraging responses to be made while stimuli were still displayed. In the present experiment, the necessity of this kind of manipulation was avoided: in a pilot study, the difficulty of the colour matching task was adjusted by changing the size of the coloured section of each line drawing. In this way, response latencies for colour matching that were slower than those occurring in a pilot identity matching task were achieved. Thus, from the outset, predictions concerning the experimental conditions in which repetition priming should be observed were not confounded with differences in baseline response latency.

Experiment 11

METHOD

Subjects. There were 48 subjects, all members of the MRC Applied Psychology Unit subject panel, mean age 29.0 years (sd=8.4). All had normal or corrected-to-normal vision. Subjects were allocated to one of three experimental conditions, with 16 subjects in each condition.

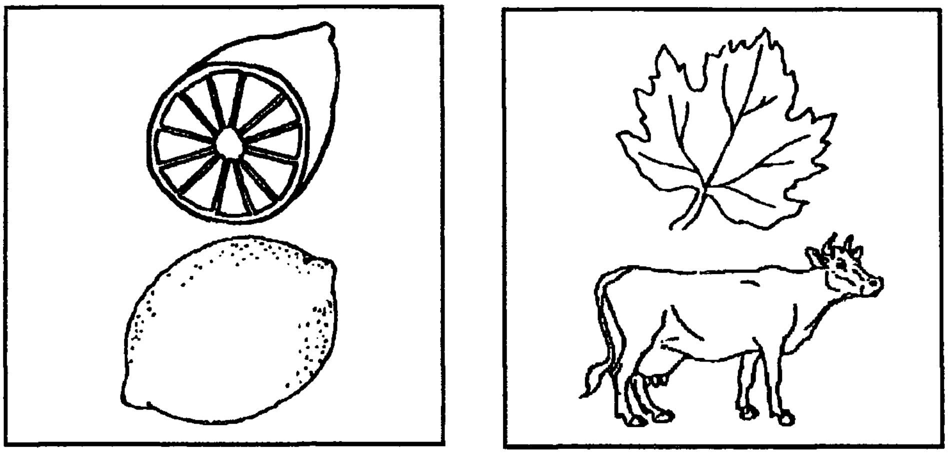
Materials. Sixty items were taken from Snodgrass and Vanderwart (1980, Appendix A). These items comprise line drawings of familiar objects. They were divided into 6 sets, each containing 10 items. The sets were matched for measures of name agreement, image agreement, familiarity, complexity and object name frequency. The means and standard deviations of each of these ratings for each of the 6 sets of stimuli are given in Appendix 1 (Sets a, b, c, d, f and j).

These materials were organised to give stimulus pairs consisting of line drawings of two objects. There were two sets of 10 *same* pairs containing two drawings of the same object, one taken from Snodgrass and Vanderwart (1980, Appendix A), the other purpose drawn. The purpose drawn pictures represented different views of the same object or different exemplars of the same entry-level category, i.e. objects that would normally have the same name. The remaining 40 items were used to generate two sets of 10 *different* pairs, containing line drawings of two different objects, taken from Snodgrass and Vanderwart (1980, Appendix A).

The stimulus pairs were presented in black against a white background, except for a small section of each line drawing that was coloured. The coloured section was pseudorandomly located and was a continuous portion of the line drawing. Colours used were red, blue, green, yellow and purple taken from the colour palette of Canvas 3.0 graphics software, each appearing in the experiment an equal number of times; the coloured sections did not relate to the identities of the object pictures.

For the same pairs described above, the coloured sections were of the same colour in both of the line drawings comprising the pair. Each colour used appeared in two same pairs in each set. The two line drawings comprising different pairs had sections of different colours. The 10 possible combinations of different colour pairings (red-blue, yellow-green etc.) were used once each in each set of 10 different pairs, with each colour appearing in the top line drawing of a pair twice, and in a bottom line drawing twice. Examples of a same pair and a different pair are given in Figure 7.1.

Figure 7.1. *Examples of Same (left) and Different (right) Object Picture Stimulus Pairs Used in Experiment 11.*



A set of filler pairs (42 pairs containing items with the same identity and 42 pairs containing items with different identities) was developed from remaining Snodgrass and Vanderwart (1980, Appendix A) items and purpose drawn pictures. Of these, in 6 pairs where objects had the same identity, the line drawings had coloured sections of the same colour. The two line drawings comprising each of the remaining 36 pairs with objects of the same identity had coloured sections of *different* colours. Six pairs in which objects had different identities had line drawings with coloured sections of different colours. The remaining 36 pairs of objects with different identities contained two line drawings with coloured sections of the *same* colour.

Design and Procedure. There were three between-subjects conditions in this experiment, described as *colour-colour* matching, *identity-identity* matching and *colour-identity* matching. These three conditions differed only in terms of the instructions given to subjects.

Each condition consisted of two phases, a training phase and a test phase. For colour-colour matching and identity-identity matching conditions, the training and test phase ran consecutively and subjects performed the same task in each. They were not told of the distinction between the two phases. For the colour-identity matching condition, the two phases were separated only by an explanation of the test phase (identity matching) instructions to subjects.

Each subject was tested individually, viewing a computer monitor at a distance of approximately 50 cm. Stimulus pairs comprising two line drawings of objects (scaled to each subtend a visual angle of 4.6° vertically; mean 5.9°, range 2.3°-9.1° horizontally) were presented on the monitor. One picture was presented directly above the other, separated by a visual angle of 1.1°. For the *same* pairs, in half the trials the Snodgrass and Vanderwart (1980, Appendix A) picture was presented above the purpose drawn picture and in half the trials below. Each picture contained a coloured section which subtended a visual angle of between 0.25° and 0.5°. Subjects were required to respond by pressing one of two alternative computer keys to indicate whether the two pictures were the same or were different. All subjects responded with the right index finger on key "M" to indicate a "same" match and with the left index finger on key "Z" to indicate a "different" match. The basis upon which this match was made differed for the three experimental conditions. In the colour-colour matching condition, subjects were instructed to respond as quickly as possible to indicate whether the two coloured sections in a stimulus pair were of the same or of different colours. In the identity-identity matching condition, subjects were instructed to respond as quickly as possible whether the two pictures in a pair depicted the same kind of object or were of different objects. In the colour-identity matching condition, subjects received colour matching instructions for the training phase of the experiment and identity matching instructions for the test phase of the experiment. Following a response, the screen was cleared and the next pair of object pictures was presented after an interval of 1500 msec. Instructions stressed that responses should be made as quickly as possible, but not at the expense of accuracy.

Practice with 4 filler pairs preceded the training phase, in which one of the *same* sets and one of the *different* sets were presented, along with 10 same identity (different colour) filler pairs and 10 different identity (same colour) filler pairs, in a random order. Thus, under both colour matching and the identity matching instructions, an equal number of "same" and "different" responses were required. The fact that the same identity filler pairs had sections of different colours, and the different identity filler pairs had sections of the same colour, meant that there was no one-to-one correspondence between the match in terms of identity and in terms of colour in the training phase. Half of the same identity pairs seen in the training phase had different coloured sections, and half had same coloured sections. Half of the different identity pairs seen had different coloured sections and half had same coloured sections. Subjects instructed to colour match could therefore not perform the task by basing their responses on the identities of the objects depicted. Similarly, subjects in the condition requiring identity matching could not base their responses on the coloured sections of the stimulus pairs presented. The training phase lasted approximately two minutes.

The test phase followed the training phase. In the case of the colour-colour matching and the identity-identity matching conditions, there was no break between the two phases. In the case of the colour-identity matching condition, the two phases were separated by instructions to change the basis of responding to the identities of the objects depicted in a stimulus pair; these instructions lasted approximately two minutes. The test phase then began with four filler pairs.

The same set and the different set presented during training were re-presented in the test phase, in each condition. These are referred to as the *primed same* and the *primed different* items. The previously unseen same set and the previously unseen different set were also presented in the test phase, and these are referred to as *unprimed same* and *unprimed different* items.

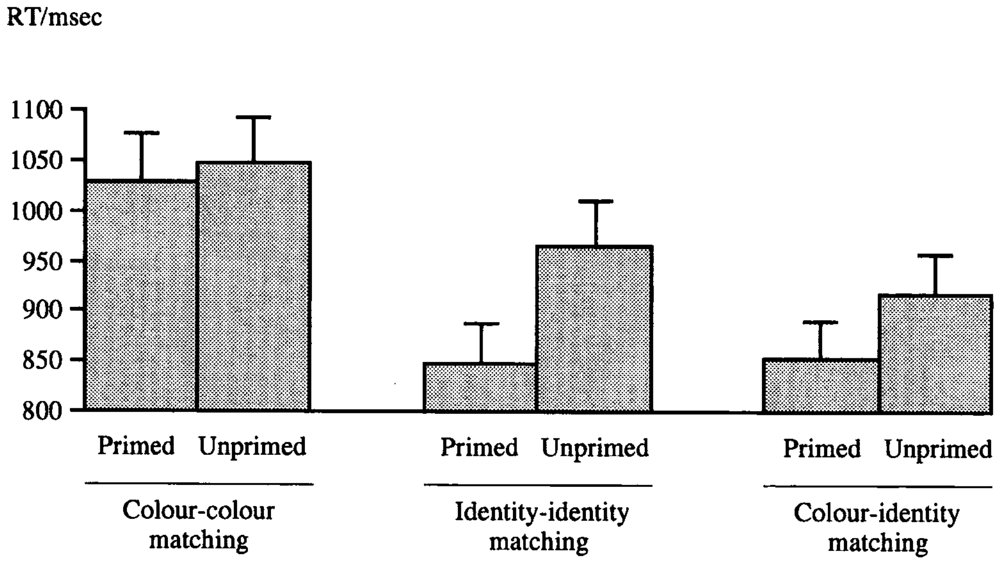
Thirty same identity filler pairs and 30 different identity filler pairs were presented in the test phase. In 25 of the same identity filler pairs the coloured sections were of different colours and in 5 the coloured sections were of the same colour. In 25 of the different identity filler pairs the coloured sections were of the same colour and in 5 the coloured sections were of different colours. Thus, in the test phase, an equal number of "same" and "different" responses were required following both the colour and the identity matching instructions. Again there was no correspondence between the identity match and the colour match of pairs in the test phase: subjects in the colour-colour matching condition would be unable to base their responses on the depicted objects' identities and subjects in the two conditions requiring matches based on identity would be unable to base their responses on the depicted objects' coloured sections. The test phase lasted approximately four and a half minutes.

All pairs were presented in a random order within each phase, with a different order used for each subject. Materials were rotated between sets across subjects.

RESULTS

The measure of interest in this experiment was the latency of correct responses made to object picture pairs in the test phase of each condition. Figure 7.2 shows the mean correct response latency in milliseconds to primed and unprimed items (collapsing across same pairs and different pairs) in each of the three experimental conditions. Latencies of over 2000 msec (3.2% of responses) and latencies of incorrect responses (3.7% of remaining responses) were excluded from the mean response latencies. Appendix 14 includes the standard deviations associated with the mean response latencies, the percentage of responses excluded with latencies over 2000 msec and the mean percent error rate to each item type.

Figure 7.2. *Experiment 11. Mean Test Phase Correct Response Latencies (in Milliseconds).* Bars indicate the standard errors of the means.



Analysis of the arc-sine transformed proportions of response latencies over 2000 msec revealed no significant differences between any of the types of item in any of the experimental conditions ($p > .1$). Analysis of the arc-sine transformed error rates revealed no significant differences between any of the types of item in any of the experimental conditions ($p > .1$). There was no apparent speed-accuracy trade-off in subjects' responding.

Three factor analyses of variance (by-subjects denoted by the subscript $_1$, by-items denoted by the subscript $_2$) were carried out on the latencies of correct responses made in the test phase of the experiment. Condition was a between-subjects and a within-items factor, with three levels (colour-colour matching, identity-identity matching and colour-identity matching). Priming (primed or unprimed) was a within-subjects and within-items factor. Item-type (same or different) was a within-subjects and between-items factor.

There was a significant main effect of condition, $F_1(2,45)=4.077$, $p<.05$; $F_2(2,76)=16.753$, $p<.0001$. Post hoc Newman-Keuls tests revealed test phase responding in the colour-colour matching condition to be significantly slower than in the identity-identity matching condition ($p_1<.05$; $p_2<.01$) and in the colour-identity matching condition ($p_1<.05$; $p_2<.01$). Latencies of responses made in the identity-identity matching and the colour-identity matching conditions did not differ in either analysis by-subjects or by-items.

There was a significant main effect of priming, $F_1(1,45)=47.030$, $p<.0001$; $F_2(1,38)=34.972$, $p<.0001$; stimulus pairs were responded to more quickly at test when repeated from the training phase than when not similarly primed.

A significant interaction between condition and priming was found, $F_1(2,45)=8.206$, $p<.001$; $F_2(2,76)=6.472$, $p<.01$. An examination of simple effects revealed statistically significant repetition priming to have occurred in the identity-identity matching condition, $F_1(1,45)=47.256$, $p<.001$; $F_2(1,38)=32.193$, $p<.001$, and in the colour-identity matching condition, $F_1(1,45)=14.868$, $p<.001$; $F_2(1,38)=13.935$, $p<.001$. There was no effect of priming in the colour-colour matching condition [$F_1(1,45)=1.318$, $p>.1$; $F_2<1$].

There was a simple effect of condition for the primed pairs, $F_1(2,45)=6.222$, $p<.01$; $F_2(2,76)=26.474$, $p<.001$. This simple effect was further examined using Newman-Keuls tests. The response latencies made to primed pairs in the identity-identity matching condition were significantly faster than those made to primed pairs in the colour-colour matching condition ($p_1<.01$; $p_2<.01$). The response latencies made to primed pairs in the colour-identity matching condition were also significantly faster than those made to primed pairs in the colour-colour matching condition ($p_1<.01$; $p_2<.01$). Latencies made to primed pairs in the identity-identity matching and the colour-identity matching conditions did not significantly differ ($p_1>.1$; $p_2>.1$). There was no significant simple effect of condition for unprimed pairs in the analysis by-subjects [$F_1(2,45)=2.388$, $p>.1$], while there was in the analysis-by items, $F_2(2,76)=5.479$, $p<.01$. Post hoc Newman-Keuls tests revealed the same pattern of statistically significantly differences as occurred for the primed stimulus pairs: responses to pairs in both the identity-identity matching condition and the colour-identity matching condition were faster than those made in the colour-colour matching condition ($p_2<.01$ in both cases). Latencies in the identity-identity matching condition and the colour-identity matching condition did not significantly differ ($p_2>.1$).

There was a significant main effect of item-type in the analysis by-subjects, $F_1(1,45)=15.703$, $p<.001$, though not in the analysis by-items, $F_2(1,38)=1.412$, $p>.1$. In the analysis by-subjects, there was a significant interaction between item-type and condition, $F_2(2,45)=4.430$, $p<.05$. Examination of simple effects revealed same pairs to have been responded to significantly more quickly than different pairs in the identity-identity matching condition, $F(1,45)=11.239$, $p<.01$, and in the colour-identity matching condition, $F(1,45)=13.306$, $p<.01$, but not in the colour-colour matching condition [$F<1$]. There was no interaction between item-type and priming [$F_1(1,45)=1.158$, $p>.1$; $F_2(1,38)=1.955$; $p>.1$], and no three-way interaction between item-type, priming and condition [$F_1(2,45)=1.262$, $p>.1$; $F_2<1$]; thus the pattern of statistically significant priming effects described above held both for latencies of responses made to same pairs and made to different pairs.

DISCUSSION

Experiment 11 examined the conditions under which repetition priming can occur, in terms of task requirements (whether access to item-specific representations was required or not) and in terms of the reinstatement of prior processing demands (whether the same task or different tasks were performed when a stimulus was first and subsequently encountered). Stimuli were pairs of simultaneously presented object pictures, each with an arbitrarily located and coloured section. Subjects were instructed to respond to the stimuli in one of two ways: matching on the basis of the objects' identities or their coloured sections. Items were repeated from a training phase in a test phase of the experiment. Results showed that there was facilitation at test in responding to repeated stimuli in the identity matching task, but not in the colour matching task. The repetition priming effect occurred in the identity matching task regardless of whether subjects had performed exactly the same identity matching task with exactly the same stimuli in the training phase of the experiment (identity-identity matching condition), or whether they had performed the very different colour matching task at training (colour-identity matching condition). There were no significant differences between the rates of errors made to any of the types of stimuli in any of the experimental conditions and so discussion is confined to the response latency data. There is no evidence to suggest that the latency data can be accounted for by a speed-accuracy trade-off in subjects' responding.

The pattern of priming effects did not differ across "same" and "different" matching responses and was evident in both analyses by-subjects and by-items. The two kinds of analysis differed in two instances. In the analysis by-subjects, latencies of responses made to unprimed items in the three conditions did not significantly differ, in the analysis by-items they did significantly differ; responses in the identity-identity matching and the colour-identity matching conditions were made significantly more quickly than those in the colour-colour matching condition, and did not differ from each other. These statistically significant differences reflect the fact that the colour matching task took longer to perform than did the identity matching task. They do not affect the interpretation of results further: simple effects of priming were evident in the identity-identity and colour-identity matching conditions and not in the colour-colour matching condition in both the analyses by-subjects and by-items. There was an effect of item-type in the analysis by-subjects (in which it was a within-subjects factor) and not the analysis by-items (in which it was a between-items factor). The reaction time advantage in making "same" judgements relative to "different" judgements is a common finding (e.g. Krueger, 1983); it was observed in the identity-identity and the colour-identity conditions, but not in the colour-colour condition. Again this finding does not affect the interpretation of results further: the pattern of statistically significant repetition priming effects held for both same pairs and different pairs.

The pattern of repetition priming effects found poses problems for an account based solely on the retrieval of prior processing episodes or reinstatement of prior processing demands (Jacoby, 1983a, 1983b; Roediger & Blaxton, 1987a, 1987b). Such episodic accounts predict priming in the colour-colour matching condition, where prior processing demands are exactly reinstated at test. This was not observed. Moreover, responses in the colour matching task took longer to make than in the identity matching task, so the absence of repetition priming in the colour matching task cannot be attributed to the speed at which the task can be performed making the effect undetectable; significant priming was observed in the identity matching task, in which responses were made more quickly.

The pattern of results observed was as predicted by an item-specific representation account of the priming effect. Performance of the identity matching task required access to representations in a system dedicated to representing the structure and form of those items for the purposes of object recognition or identification. Activation (or sometimes creation) of such representations has been described as at least one locus of repetition priming effects (Morton, 1969, 1979; Tulving & Schacter, 1990). The colour matching task does not require access to such representations of the identities of individual items, and so no repetition effects were evident in this task; colour information is represented elsewhere (Desimone *et al.*, 1985; Meadows, 1974; Ostergaard & Davidoff, 1985).

The findings of this experiment pose problems for the episodic class of accounts for a second reason. The amount of repetition priming occurring in the identity matching task at test did not differ when the training phase task was one of colour matching from when it was one of identity matching. That is, a change in task between training phase and test did not attenuate the repetition effect. Such attenuation is predicted by episodic accounts as a change in task results in a less close reinstatement of prior processing than does performing the same task in both phases of the experiment. Episodic accounts argue that it is this closeness of reinstatement of processing demands that determines the magnitude of the repetition priming effect. These results are, however, again entirely consistent with the locus of the effect being activation of item-specific representations employed in the identification of stimuli. Here a distinction is made between representations to which a task requires access in order to be completed and representations which automatically become activated during performance of a task. Both the identity matching and the colour matching task will result in automatic activation of item-specific representations in the training phase of the experiment, as the recognition of familiar objects is deemed to proceed in a mandatory fashion (Ellis *et al.*, 1990; Fodor, 1983). As a consequence, both tasks produce repetition priming to repeated stimuli in the test phase when the identity matching task is performed, as this requires access to the item-specific representations and will benefit from their prior activation. The colour matching task does not require access to these representations in order to be completed, and hence performance of this task does not benefit from the prior activation of item-specific representations.

These results can be contrasted with those of other studies in which attenuation of repetition priming as a consequence of changing task between training and test has been observed (Durso & Johnson, 1979; Lachman & Lachman, 1980; Logan, 1990). In these studies, however, the change in task performed at training involved a change in responses made on the basis of the identification and naming of stimuli to responses made on the basis of either identification or naming alone (in the three studies cited above, from picture naming to word naming; from picture naming to responding to the items as distractors in a recognition memory test; from pronunciation decisions to lexical decisions, respectively). These changes would be expected to attenuate repetition priming if it is assumed that processes in both the identification and the naming of items can be a locus of the effect (cf. Wheeldon & Monsell, 1992). In studies where task demands have been changed without a concomitant change in the number of loci of repetition priming potentially affecting task performance, priming has not been observed to be attenuated (Ellis *et al.*, 1990; Valentine *et al.*, 1993; Experiments 1 & 2 of this thesis).

It might be argued that repetition priming (in Experiment 11) occurred in the two conditions requiring identity matching at test, and not in the condition requiring colour matching, because the identities of the objects comprising stimulus pairs were not repeated across trials, whereas each colour in the experiment was used in a number of stimulus pairs.

Identity could therefore have provided a unique retrieval cue for the training phase encounter with a primed stimulus pair, whereas colour provided a retrieval cue for a number of earlier trials. However, the coloured section *and* its location within the contours of the line drawing of each object was uniquely specified for each item comprising a stimulus pair, so the absence of repetition priming in the colour-colour matching condition cannot be accounted for in this way.

Episodic accounts of repetition priming can be seen as an extension of the transfer appropriate processing framework described by Morris *et al.* (1977). This framework was developed to account for the apparent dependence of memory performance on the interaction between encoding and retrieval operations. For at least one memory phenomenon however - the repetition priming effect under the conditions described here - memory performance is best understood in terms of the activation or creation of representations in a system responsible for the initial identification of individual stimuli. The representations are not of entire processing episodes, a fact reflected in the kinds of tasks in which repetition priming effects are evident. The results of Experiment 11 place clear constraints upon the generality of such accounts of memory performance based on the reinstatement of prior processing demands; they are more appropriate to some memory phenomena than others.

8 SUMMARY, DISCUSSION AND CONCLUSIONS

The results of the eleven experiments reported in this thesis are summarised below, followed by a discussion of their implications for accounts of repetition priming. A number of topics in the literature are then discussed in light of these findings; namely the repetition priming of novel information and its implications for explanations of the relationship between conscious awareness and memory, the role of pre-existing representations in repetition priming, and the exclusivity of accounts of the effect. Suggestions for further research are made where appropriate.

SUMMARY OF EXPERIMENTAL RESULTS

On the basis of the experiments reported in Chapter 2, a locus of the repetition priming effect was described. In these experiments, stimuli consisted of pairs of simultaneously presented object pictures and names, and the task was to make a single response based on some comparison of the two. In Experiments 1, 2 and 3, a subset of items were repeated from an initial training phase in a subsequent test phase. Repetition priming was revealed in faster responding to repeated stimulus pairs as compared to stimulus pairs presented for the first time in the test phase. Of critical interest was the extent to which recombining the pairings of items between training and test would affect the degree of priming observed. No significant attenuation of the priming effect following the re-pairing of items was observed in Experiment 1, where the task was same/different matching of the identities of the items comprising each stimulus pair. Experiment 3 replicated this result, and allowed for a within-items analysis.

In Experiment 2, the task in the training phase was same/different matching on the basis of category membership of the two items comprising each stimulus pair. The categories chosen were the four combinations resulting from contrasting 'man-made' versus 'natural', and 'could be found indoors' versus 'only ever found outdoors'. This task was designed to result in more elaborative processing of the simultaneously presented items as a pair. The test phase task was one of same/different matching of the identities of the items. Again, there was no significant attenuation of repetition priming as a result of recombining the pairings of items between training and test. The magnitude and pattern of the priming effects observed in Experiments 1 and 2 did not significantly differ.

Experiment 4 had a training phase identical to that of Experiment 2. The test phase, however, consisted of a surprise forced-choice recognition memory test for the pairings of items seen in the training phase. Targets were pairs of items that had been presented together at training, distractors were two items, both also presented at training, but not paired with each other. Subjects were able to recognise, at well above chance levels, the pairings of items following the same encoding conditions under which there was no evidence of repetition priming being sensitive to these pairings. This result was not an artefact of the recognition memory test being shorter than the priming test phase.

The results of the first four experiments reveal, then, that repetition priming of a pair of simultaneously presented stimuli depends upon the fact that both the items in the pair have been encountered at training, not that they have been presented and responded to together. While repetition priming is not sensitive to the pairings of items, this information can still be available to subjects as a basis for making recognition memory judgements.

The locus of the priming effect described on the basis of the experiments reported in Chapter 2 was further refined in Chapter 3. Experiment 5 examined priming between representational domains, again using the speed same/different matching task. Having seen a written object name did not facilitate subsequent processing of a picture of that object, and vice versa. Experiment 6 examined the effects upon repetition priming of recombining the pairings of items, between training and test, when all items were drawn from the single representational domain of object pictures. Again, the degree to which responding to recombined pairs was facilitated upon repetition did not reliably differ from the degree to which responding to pairs repeated intact was facilitated.

The representations underlying repetition priming in the same/different matching task were therefore shown to be domain-specific and not conceptual in nature. What's more, the independent representation of two simultaneously presented items, as had been demonstrated in Experiments 1, 2 and 3, did not result from the fact that the two items in a pair were drawn from different domains.

The extent to which repetition priming in the same/different matching task was affected by changing the decision and response required to individual items was examined in Chapter 4. In Experiment 7, for a subset of stimuli, the pairings of pictures and words that required a "same" response at training were recombined to give stimulus pairs that required a "different" response in the test phase. Responses to these stimulus pairs were inhibited relative to responses made to unprimed stimulus pairs. At the same time, significant repetition priming of stimuli simply repeated from training at test, and of pairs recombined between training and test without requiring an associated change in response, did not occur. Experiment 8 revealed that the inhibition of the recombined-from-same stimulus pairs was eliminated by the addition of filler items. The addition of filler items also increased the differences between latencies to pairs repeated from training intact, or recombined without a change in response required, and latencies to unprimed items, though these changes were not statistically significant.

The results of Experiments 7 and 8 suggest that any role for repeating the decision and response made to stimuli in producing repetition priming resulted from subjects' use of explicit memory for the training phase encounters with stimuli, rather than reflecting automatic priming effects.

Chapter 5 contained a single experiment - Experiment 9 - which examined the effects of changing the interpretation of homographs between training and test upon repetition priming. Homographs were initially biased towards one interpretation by an accompanying word at training. As much priming of homographs repeated accompanied by a picture that changed the interpretation demanded was observed at test, as of homographs accompanied by a picture that preserved the interpretation towards which they were initially biased. Within the same experiment, subjects' recognition memory for the direction in which homographs had been biased at training was assessed; subjects performed well above chance levels on this task. Having performed the recognition memory test before the repetition priming test did not affect the pattern of results on the repetition priming test, despite subjects having had their attention drawn to the fact that the interpretation demanded of homographs could be changed by the meaning of accompanying stimuli.

This experiment revealed that reinstating the interpretation of a stimulus, or otherwise, played no role in producing the repetition priming effect. This information was still available to subjects as a basis for their recognition memory judgements.

Chapter 6 contained Experiment 10, which addressed the necessity of the pre-existence of representations of the stimuli on, first, whether repetition priming occurred at all in the speeded same/different matching task, and, second, on the item-specificity of priming of two simultaneously presented stimuli. Materials consisted of line drawings of novel objects. Again, the logic of recombining the pairings of a subset of items between training and test encounters was used. Once more, there was no significant attenuation of the repetition priming effect as a result of this manipulation.

This experiment revealed that repetition priming in the speeded same/different matching task need not depend upon the activation of pre-existing representations, or the strengthening of pre-existing connections. Nor does the independence of the representation of each of two simultaneously presented items in the kind of memory underlying repetition priming require pre-existing representations of those items.

The final experiment in this thesis, Experiment 11, was described in Chapter 7. This experiment again used the speeded same/different matching task, but examined whether priming depended upon the task at test requiring the identification of stimuli. Stimuli were pairs of line drawings of familiar objects. No priming was found when the task at training and at test was one of matching small coloured sections of the objects. Priming was found when the task at both training and test was one of matching on the basis of the identities of the objects depicted. This occurred even though decisions in this task took less time to perform than in the colour matching task. Importantly, priming was also observed when matching was performed on the basis of colour at training and on the basis of identity at test. The degree of priming seen in this last condition did not differ from that observed when the same task (identity matching) was performed in both phases of the experiment.

Experiment 11 revealed, therefore, that repetition priming only occurred when the task required that subjects access representations of the identities of the stimuli presented at test. The pattern of priming effects was not determined by the extent that processing demands at training and test overlapped.

IMPLICATIONS FOR EPISODIC ACCOUNTS OF REPETITION PRIMING

The experiments described above purely in terms of their outcomes were, of course, conducted because they address the differing predictions of different theoretical accounts of repetition priming. Some authors (e.g. Jacoby, 1983a, 1983b; Jacoby & Brooks, 1984) argue that the effect results from the retrieval of records of prior processing episodes. Closely related to this view is an account phrased in terms of transfer appropriate processing; repetition priming is described as resulting from the reinstatement of prior processing demands (e.g. Roediger & Blaxton, 1987a, 1987b). As both of these kinds of account describe priming as a function of the extent to which processing operations at training overlap with those occurring when a stimulus is repeated at test, they are subsumed under the general label "episodic accounts" here. None of the experiments described in this thesis provides support for this class of theoretical account.

In Experiment 1, an episodic account would predict less priming of the stimulus pairs recombined between training and test than of the stimulus pairs presented exactly as they had been at the training. While both the picture and the word in a recombined stimulus pair had been seen at training, they had not been presented together, and a response had not been made on the basis of a comparison of the two. A recombined pair at test would therefore act as a less efficient retrieval cue for a training phase processing episode than would a stimulus pair repeated with the pairing of items preserved; less facilitation in responding to the recombined pair should be observed according to such an account. In fact, no significant difference between the response latencies made to the recombined pairs and the pairs repeated intact was observed, suggesting a negligible role, if any at all, for the retrieval of prior processing episodes, or the reinstatement of prior processing demands, in determining the priming effect. This pattern of results was replicated in Experiment 3, also occurred in

Experiment 6, where all stimuli were pictures of familiar objects, and in Experiment 10, where stimuli were pictures of unfamiliar objects.

The same pattern of results also occurred in Experiment 2, where in the training phase subjects performed a categorisation task designed to increase the likelihood that the two items comprising a stimulus pair would be represented together in memory. There was no evidence to support an episodic account of the priming effect. Experiment 4 revealed that under these same encoding conditions subjects had well above chance recognition memory for the pairings of items that they had responded to at training. This finding is important because it mitigates against certain alternative explanations of the results of Experiments 1, 2, 3 and 6. The finding of no difference in the degree to which recombined pairs and pairs repeated intact were primed provides no support for an episodic account, but could have occurred for a variety of reasons. For example, it could be that subjects were simply unable to retain any record of the pairings of items, given the encoding conditions of the same/different matching task. Experiment 4 revealed that this information *was* available to subjects, as a basis for responding on a different kind of memory test. A post hoc analysis revealed that the differential sensitivity of responses in the priming test and the recognition memory test to the pairings of items was not due to the fact that there was a longer lag (in terms of time and number of intervening trials) between the training and test phase encounters with stimuli in the priming test. It cannot be argued, under these circumstances, that the null effect of recombining the pairings of items reflected the fact that subjects simply did not have this information available to them. Rather, the lack of an effect of recombining the pairings of items on repetition priming reflects the fact that novel associations between items are not stored in the memory representations that underlie the priming effect, while they are stored in the representations that underlie recognition memory.

In Experiment 9, the interpretation demanded of homographs was manipulated between training and test phase encounters with the words. In earlier experiments (1, 2, 3 and 6) the context in which each item occurred was manipulated, and this context consisted of the nominal association between two simultaneously presented items. In Experiment 9, the context in which homograph occurred (its bias word at training and the picture presented with it at test) was not nominal, it determined the interpretation of each word at which subjects arrived. It has been argued that it is the reinstatement of "interpretive" encoding mechanisms, rather than elaborative processing performed subsequent to stimulus interpretation, that produces repetition priming (Graf & Mandler, 1984; Masson & MacLeod, 1992; Micco & Masson, 1991). Experiment 9 provided no evidence to support this variant of the episodic class of accounts. Changing the interpretation demanded of homographs between training and test encounters produced no attenuation of the degree to which processing of those items was facilitated at test. In fact, the mean response latency made to the changed-interpretation stimulus pairs was 1 millisecond faster than that made to the preserved-interpretation pairs; it cannot be argued that there was even a negligible role for the retrieval of prior processing episodes in producing the priming effect that was observed. The inclusion of a recognition memory test in Experiment 9 mitigated against the possibility that the interpretation of the homographs was not influenced by the bias words accompanying them at training and hence had no effect on the repetition priming measure; subjects were able to recognise which bias words had accompanied the homographs.

The results of the final experiment of this thesis, Experiment 11, provide a different kind of evidence that, again, poses problems for episodic accounts of repetition priming. There was as much repetition priming observed when subjects performed a speeded same/different matching task based on the identities of depicted objects at test, regardless of whether that same identity matching task or matching based on coloured sections contained within the pictures was performed at training (identity-identity matching and colour-identity matching conditions, respectively). There was no reliable repetition priming effect when subjects performed the colour matching task at both training and test. So, less exactly reinstating prior processing demands (colour-identity matching as compared to identity-identity matching) did not attenuate repetition priming, while no priming was observed in a circumstance where prior processing demands were exactly reinstated (colour-colour matching).

Taken together, then, the results of the experiments contained in this thesis are clearly not compatible with accounts in which it is the degree to which prior processing demands are reinstated that determines the repetition priming effect, whether such an account is phrased in terms of the retrieval of prior processing episodes (Jacoby, 1983a, 1983b) or in terms of transfer appropriate processing (Roediger & Blaxton, 1987a, 1987b). The next question to ask is, what *can* account for the results of these experiments?

AN ITEM-SPECIFIC LOCUS OF REPETITION PRIMING

While the results summarised above pose problems for an episodic account of repetition priming, they are entirely consistent with an account of the effect based on the facilitated activation of representations of the structure and form of individual items, used for the purposes of identification. Such a notion can be traced back to Morton's (1969, 1979) logogen model; Tulving and Schacter (1990) present a more recent version (although, perhaps surprisingly, despite a decade's advantage, not one that provides more clearly testable predictions). The results of the experiments contained in this thesis also address differences between variants within this class of accounts.

The representations are item-specific. Evidence that the representations in memory underlying the priming effect are of *individual* items is provided by Experiments 1, 2, 3, 6 and 10. In each of these experiments, the integrity or otherwise of stimulus pairings (where items in a pair were presented simultaneously and the task required a single response) did not significantly attenuate the degree to which responding was facilitated upon repetition. These results are compatible with an item-specific representation account of repetition priming, and not with any information about the pairings of items being encoded in the representations underlying the effect.

It must be noted that this conclusion rests on a null result, that is, the finding of *no significant difference* in the latencies of responses made to the primed intact pairs and the recombined pairs. In fact, in all five experiments the non-significant difference that was observed, no matter how small, was in the direction of faster responses to the primed intact pairs than the recombined pairs. It is therefore more appropriate to conclude that there was a *negligible* role for the retrieval of prior processing episodes in producing the significant priming effects that were observed, and that these results are best accounted for by an item-specific representation account of the effect. Experiment 4 revealed that subjects were able to recognise the pairings of items, even though this information did not affect priming. This serves as a manipulation check; it cannot be argued that information about the pairings of items could simply not be encoded or retained by subjects given the training conditions. There was also reliable facilitation of responding to both the primed intact and the recombined items, as compared to the unprimed items, in each experiment. This serves as a measurement check; it cannot be argued that the response measure was not sensitive enough to reveal any priming effects at all. Therefore, "a good effort" (Frick, 1995) was made to find a reliable effect of recombining the pairings of items, if one existed.

The absence of novel associative repetition priming following a single training phase encounter with the stimuli is consistent with findings of Dagenbach *et al.* (1990). They found that presenting one member of a word pair prior to its partner, which was a target in a lexical decision task, only facilitated responding to that partner after lengthy study of the pairings of the two items, and when one of the items was previously unfamiliar to subjects. Such extensive study is not necessary to produce repetition priming of individual words and objects; this can occur after a single training phase trial.

The representations are perceptual. Having established that the memory representations underlying repetition priming in the same/different matching task are of individual items, we can consider more closely the nature of these representations. In Experiment 5, changing the representational domain of items between training and test, from pictures to words and from words to pictures, was found to completely eliminate the priming effect. The different surface forms of each stimulus share conceptual representations (they have the same meaning) but do not share perceptual representations (they do not have the same physical structure). The results of Experiment 5 therefore reveal the representations underlying the priming effect to be perceptual in nature; there was no facilitation in the processing of items as a consequence of the repetition of conceptual information. (Such "self priming" would have been predicted had stimuli been repeated at very short SOAs; Calder, Young, Benson & Perret, in press; Vanderwart, 1984.) Further support for the representations being perceptual in nature comes from Experiment 9, in which changing the interpretation demanded of homographs between training and test did not attenuate the degree to which processing of these items was facilitated by repetition. Changing the interpretation demanded of the words would be expected to attenuate repetition priming if the locus of the effect was semantic, or had a component that was semantic in nature. If the locus of the effect were perceptual, however, one would predict the pattern of results observed; alternative interpretations of a homograph share a perceptual form - by definition.

It is possible that the priming effects in these experiments resulted from a change in the strength of the connections between item-specific perceptual representations and semantic representations. Although semantic representations will be shared by stimuli presented in different domains (e.g. a picture of an object and its name), the connections from perceptual representations to these shared representations will not be. Such a locus for repetition priming has been proposed (Burton *et al.*, 1990; Monsell, 1991). If this is to be the locus of the priming effect, rather than activation of the perceptual representations themselves, then in order to accommodate the results of Experiment 9, it must be the case that the connections from the perceptual representation of a homograph to *all* its various semantic representations be strengthened in parallel. These changes must take place before there is any competition between the different interpretations of the word, which must occur in order to arrive at the meaning appropriate for the context in which the word appears. In Experiment 10, reliable repetition priming of novel objects was obtained, which shows that repetition priming can occur for stimuli that will have no connections to semantic representations. This result cannot be accommodated by the changes-in-connections view, but must rather reflect the creation of a representation of the perceptual structure and form of an individual item, created after a single encounter with the item, and capable of producing facilitation in the processing of that same item when repeated. Describing the locus of repetition priming in this way is *necessary* in order to account for the results of Experiment 10, and priming at this locus could account for the results of *all* the experiments reported in this thesis, whether stimuli were familiar or unfamiliar, words or pictures.

Experiment 7 was carried out to examine whether there was any role for repeating the same response associated with stimuli in producing the priming effect in the same/different matching task employed in Experiments 1, 2, 3, 5 and 6. As well as recombining the pairings of items within a set of stimuli between training and test, as had occurred in Experiments 1, 2, 3 and 6, Experiment 7 included a set of stimuli in which the pairings of items were recombined and a different response was required at test than had been required at training. In this set, pictures and words that were initially seen as members of same pairs were repeated as members of different pairs. If the representations underlying the priming effect were entirely perceptual in nature, then this manipulation of response mapping would not be expected to have any effect upon the magnitude of priming observed. Some authors (e.g. Logan, 1990) would predict an effect of such a manipulation, as the decision made and response executed are part of the processing episode associated with that item. In fact, responses to these stimuli were inhibited relative to stimuli that were not presented in the training phase at all. Experiment 8 revealed that this inhibition was eliminated by the addition of filler items, consistent with subjects having used explicit memory for the responses associated with stimuli as a basis for responding. Why changing stimulus response mappings should be so salient as to change subjects' basis for responding to include this component, when there had been no evidence for explicit memory playing such a role in the earlier experiments, is not clear. The results of Experiments 7 and 8 do not, however, require a change in the conclusions drawn from those earlier experiments.

The representations are independent of those that mediate recognition memory. Experiment 4 revealed that subjects had above-chance recognition memory for the pairings of items. After identical encoding conditions, those pairings had played no role in producing repetition priming in Experiment 2. This dissociation between performance on the two types of memory test did not result from the fact that the recognition test had fewer trials than the priming test, and hence each trial occurred after a shorter delay and after fewer intervening items in the former. Rather, this dissociation reflects that fact that the representations underlying the priming effect do not encode information about novel associations (i.e. they are item-specific) whereas the representations underlying recognition memory do so. Importantly, the dissociation observed here is in the opposite direction to that more frequently reported: a variable affecting recognition and recall with repetition priming of the same information being unaffected, the most notable example of which being whether subjects are amnesic or memory unimpaired (e.g. Schacter, 1987). Having evidence for dissociations in both directions is important because such double dissociations rule out certain explanations that are possible for single dissociations. A single dissociation between performance on two tasks can occur because one of the tasks is easier than the other, while they depend upon common processing mechanisms. That the representations mediating priming and recognition memory have different properties is consistent with the notion that two functionally separate systems mediate performance on the two types of test.

Tulving and Schacter (1990) describe repetition priming as resulting from a stimulus being related to information stored in the "perceptual representation system" (PRS); perception is facilitated independently of any recollection of the prior encounter with that item. Explicit memory, usually reflected in performance on a test of recognition or recall, depends upon the operation of an episodic memory system. This idea is not a new one; Tulving and Schacter's distinction between the PRS and episodic memory is a more seasoned re-description of distinctions between memory systems that have been made elsewhere in the literature (e.g. Cohen & Squire, 1980; Tulving, 1983; Weiskrantz, 1987). It has been argued that it is not necessary to postulate independent memory systems in order to account for the dissociations between priming and recognition and recall (Roediger, 1990; Roediger, Rajaram & Srinivas, 1990). Indeed, as performance on different priming tests is known to be stochastically independent (Blaxton, 1989; Srinivas & Roediger, 1990; Witherspoon & Moscovitch, 1989), a strategy of postulating independent systems to account for each dissociation would lead to a proliferation of representational systems. There is, however, converging evidence from neuropsychology for the existence of independent domain-specific perceptual representation systems (see, e.g., Ellis & Young, 1988) and an independent episodic memory system (see, e.g., Schacter, 1987).

The dissociation between recognition memory and the repetition priming effect reveals that the speeded same/different matching task was "process pure", in the sense that responses in the test phase were not based on subjects' explicit memory for stimulus pairs presented at training (except, as has been mentioned, in Experiment 7). If explicit memory had been used, then an effect of recombining the pairings of items between training and test would have been expected. Such an effect was not observed. The results of these experiments are therefore consistent with the possibility discussed in the introduction to this thesis, that the priming of novel associations, when observed in other tasks, may reflect subjects' use of explicit memory as a basis for responding. For example, in the cued word-stem competition task (Graf & Schacter, 1985) there are no time constraints to prevent subjects from consciously and effortfully using the cued stem as a retrieval cue for target words that were presented at training. There is other evidence to support this view; its implications for describing the functional deficit in amnesia will be discussed in a later section.

The representations are used for the identification of stimuli. A number of properties of the representations underlying repetition priming have been described. One might ask what the functional significance of these representations is. Pre-semantic, item-specific representations (rather than representations of entire processing episodes) are incorporated into many theories of object and word recognition. Marr (1982) provides perhaps the most cogent argument for the necessity of such representations. Information entering the visual system, the pattern of light on each retina, is constantly changing due to movement of the eyes, movement of the observer relative to objects in the visual world, movement of those objects relative to each other, changes in lighting conditions etc. In order to recognise objects (and hence draw upon stored knowledge of how to interact with them) some of this information must be abandoned; object recognition proceeds so as to abstract across irrelevant information while continuing to represent information that defines the identity of an object. Other information, for example about the distance of objects, is also important and is represented elsewhere. Marr described a series of processing stages by which different kinds of representation are computed, resulting in an object-centred structural description. This item-specific description is computed before the identity of the object is known; a stored catalogue of known object descriptions is then consulted in order for identification to occur. Different theories of object recognition provide different conceptualisations of the exact form the item-specific representations take, for example, whether they are completely viewpoint invariant (e.g. Marr & Nishihara, 1978), whether they are viewpoint invariant to the extent that features and the relations between features are recoverable (e.g. Biederman, 1987), or whether the specific view of an object is transformed to match a single, stored canonical view (e.g. Ullman, 1989), or the closest of several prototypical views (e.g. Tarr & Pinker, 1989). Such issues are still unresolved. What is important here is to note that the item-specific representations described on the basis of the repetition priming experiments contained in this thesis are likely to be those that play a necessary functional role in the recognition of objects and words.

Empirical support for the item-specific representations' role in the identification of stimuli comes from the final experiment of this thesis. In Experiment 11, facilitated processing of stimuli as a consequence of their repetition was observed in a task that required identification of those stimuli (the identity-identity matching condition) but not in a task that did not require identification (colour-colour matching condition). This pattern of results suggests that access to representations of the identities of items is necessary for repetition priming to be observed, consistent with the facilitated activation of such representations of identity being the locus of the priming effect.

Performing the colour matching task in the training phase of the experiment also produced priming in the identity matching task at test; in fact, there was no statistical difference in the degree to which responses to repeated stimuli in the identity matching task were primed by identity matching and colour matching tasks at training. It appears that representations of the identities of seen objects are activated regardless of the task being performed at the time, although repetition priming is only evident in a task that ***requires*** access to those representations. These results parallel those of Ellis *et al.* (1990), who found similar amounts of priming of familiarity decisions to familiar faces upon repetition, whether the same familiarity decision task was performed at training, or a sex or expression decision task. No priming was observed in the sex decision or expression decision tasks at test, regardless of whether the identical task was performed at training. The familiarity decision task requires access to representations of the identities of the known faces, while sex and expression decisions do not. The results of Experiment 11, like those of Ellis *et al.*'s (1990) study, are consistent with the notion that the cognitive systems mediating the processing of sensory input (input modules) operate in a mandatory fashion (Fodor, 1983).

Having described a functional role for the kind of representations deemed to underlie repetition priming observed in the experiments reported here, one might ask what adaptive purpose repetition priming itself serves. The effect refers to the facilitation in the processing of a stimulus as a function of a prior encounter with that same stimulus. Having identified an object or word previously, it will benefit the individual to be able to recognise that same item more quickly when encountered again - the item may have been temporarily occluded from view by the presence of another item, or may have fallen from view by movement of the individual. Upon returning into view, it is adaptive for the identity of that item to be more readily available to the individual than otherwise. The recognition of an item also results in a long lasting modification of the stored representation of that item such that the representation incorporates some information about this specific encounter, weighted according to past encounters with the same item. Repetition priming, therefore, reflects the development of representations in a system dedicated to categorising a variety of stimulus inputs as having the same identity.

REPETITION PRIMING OF NOVEL INFORMATION

Despite some early reports of an absence of repetition priming of nonwords using the lexical decision task (e.g. Bentin & Moscovitch, 1988; Forbach, Stanners & Hochhaus, 1974), it is now clearly established that the processing of certain kinds novel information is facilitated as a consequence of that information being repeated.

The lack of priming of novel items in the lexical decision task can be explained by the confounding of the familiarity associated with repeated items and their lexical status (Feustel *et al.*, 1983). Robust priming of nonwords has been reported in tasks such as perceptual identification (Bowers, 1994; Feustel *et al.*, 1983), reading speed (Carr *et al.*, 1989) and "most word-like" judgement (Dorfman, 1994) where confounding of familiarity and response required does not occur. Nonword priming has also been reported to be preserved in amnesic patients (Cermak, Blackford, O'Connor & Bleich, 1988; Gabrieli & Keane, 1988; Haist, Musen & Squire, 1991) and is therefore unlikely to reflect subjects' use of explicit memory for the stimuli as a basis for responding. Similarly, repetition priming of novel non-verbal stimuli has been reported in a variety of experimental tasks, for example in brightness decisions to unfamiliar shapes (Mandler, Nakamura & Van Zandt, 1987), copying briefly presented patterns (Musen & Treisman, 1990), object reality decisions (Kroll & Potter, 1984) and possible/impossible decisions to briefly presented structures (Schacter *et al.*, 1990). It was observed here in Experiment 10. Again, preserved priming of this kind of novel information has been reported in amnesic patients (e.g. Gabrieli, Milberg, Keane & Corkin, 1990; Schacter, Tharan, Cooper & Rubens, 1991).

The multifarious examples of priming of nonwords and novel objects can be contrasted with the lack of evidence for the priming of another kind of novel information, namely novel *associations* between items. This evidence was reviewed in Chapter 1. The task used most extensively to examine priming of novel associations, that is, the arbitrary pairings of items, has been cued word-stem completion. Despite being observed in normal subjects, it appears that the effect only occurs in the subgroup of subjects who report being aware that stimuli presented at training could be used to complete the stems presented at test (Bowers & Schacter, 1990). The effect has been found to be absent in amnesic patients (Mayes & Gooding, 1989; Cermak, Bleich & Blackford, 1988), or has been found to be correlated with the severity of the patients' memory deficits (Schacter & Graf, 1986; Shimamura & Squire, 1989). These facts together suggest that the priming of novel associations on the cued word-stem completion task is mediated by strategic use of explicit memory, rather than reflecting automatic memory processes that can be dissociated from explicit memory. Indeed, Gooding (unpublished; cited in Mayes, 1992) has found that when the separate contributions of automatic and controlled processes to cued word-stem completion are estimated, using a technique described as the processes dissociation procedure (Jacoby, 1991), then priming of the novel associations is mediated entirely by controlled use of memory. It must be remembered, though, that this issue is not fully resolved. There are some properties of the priming of novel associations which do not sit so easily with the notion that it results from the use of explicit memory. The priming of novel associations has been reported to be affected by a change in the modality in which stimuli were presented between training and test, unlike recall (Graf & Schacter 1989); and conversely, proactive and retroactive interference have been reported to affect recall of novel associations but not their priming (Graf & Schacter, 1987). Priming of novel associations has also been reported to be intact in a densely amnesic subject (Cermak, Blackford, O'Connor & Bleich, 1988). It is perhaps more circumspect to argue that the *weight* of evidence suggests that priming of novel associations on the cued word-stem completion task is mediated by strategic use of explicit memory.

A similar case for the use of explicit memory as a basis for responding can be made when the lexical decision task has been used to examine the priming of novel associations and the procedure has included a sizeable temporal delay between presentation of the two items comprising a stimulus pair (e.g. McKoon & Ratcliff, 1979). This delay would provide subjects with an opportunity to use the first item as a retrieval cue for the trained pair, and thus generate an expectancy about the identity of the item to occur on the subsequent trial. This expectancy would facilitate the identification of items in intact pairings but not in recombined pairings, thus giving a pattern of response latencies indicating that there is a contribution from the novel associations to the priming effect. When short SOAs are employed (Neely & Durgunoglu, 1985), or stimuli are presented simultaneously (Carroll & Kirsner, 1982), thereby reducing the likelihood of strategic retrieval, there is no evidence for the contribution of the novel associations between items in producing the priming observed.

The procedure employed in Experiments 1, 2, 3, 6 and 10 is essentially a speeded analogue of the cued word-stem completion task. Although using picture-word pairs (Experiments 1, 2 and 3) or pairs of pictures (Experiments 6 and 10) rather than pairs of words, the procedure employed the same logic of comparing facilitation in responding to repeated intact and recombined pairs to get a measure of repetition priming of novel associations between items. Responses in this speeded task are less likely to be based on subjects' explicit memory for the repeated stimuli, if it is assumed that such retrieval is more time consuming than the processes of stimulus identification and response selection necessary for accurate performance in the absence of such retrieval. The dissociation between priming (Experiment 2) and recognition memory (Experiment 4) supports this assumption. The results of Experiments 1, 2, 3, 6 and 10 are therefore also consistent with the notion that repetition priming of novel associations, when it has been observed, is based upon subjects' explicit memory for the trained pairings of items.

Whether amnesic patients show preserved priming of novel associations is an important piece of information in characterising their functional deficit. (And clearly, whether novel associative priming occurs or not even in normal subjects is crucial to this issue.) Schacter (1990) makes a distinction between *first-order* and *second-order* explanations of the dissociation between impaired awareness of past events and preserved implicit, or unaware, memory for past events. According to a first-order explanation, the dissociation occurs because of damage to a system that underlies domain-specific conscious awareness, or a disconnection of a unitary conscious awareness system from the cognitive systems that underlie memory. The systems underlying memory encoding, storage and retrieval are not themselves damaged, and hence there is evidence from indirect tests of memory, which do not require the conscious recollection of past events, of the influence of past events on current behaviour in amnesic patients: Amnesics show preserved repetition priming. An example of a first-order account of the deficit in amnesia is presented by Schacter (1989). A Conscious Awareness System (CAS) is described, functionally and anatomically distinct from other aspects of information processing. Anterograde amnesia is attributed to the disconnection of the CAS from memory systems, with repetition priming reflecting the preserved operation of those memory systems. As the CAS's links with systems subserving language processing, object recognition, face recognition, semantic memory and executive functions are preserved, the amnesic patient has preserved language, perception, knowledge and intellect. Similarly, disconnections between other domain-specific processing systems and the CAS, as a result of brain damage, would produce other kinds of domain-specific deficits of conscious awareness according to this account, with evidence for intact information processing within those domains being obtainable on tests not requiring use of the CAS. For example, a disconnection of the CAS from the cognitive systems that mediate face perception would result in the individual being unable to consciously recognise familiar faces, yet demonstrating differential processing of familiar and unfamiliar faces on other kinds of test. Such patterns of performance in prosopagnosic patients have been described (Bauer, 1984; De Haan, Young & Newcombe, 1987).

A different kind of first-order explanation of the dissociation between performance on direct and indirect tests of memory is provided by Jacoby (1984; Jacoby, Kelley & Dywan, 1989). According to Jacoby, conscious awareness of memory occurs when the fluent processing of information, resulting from its retrieval from memory, is attributed to that information having been encountered before. The conscious experience of remembering results from the attribution process, and not from the operation of memory systems *per se*; their operation can be observed without any involvement of conscious awareness in performance of indirect tests of memory.

According to a second-order explanation, the dissociation between performance on repetition priming and explicit memory tests results, not from a deficit in, or disconnection of, systems responsible for the generation of awareness, but from a deficit in certain aspects of memory processing that are accompanied by conscious awareness. (Conscious awareness need not be a property of some other system, or depend on other types of processing; it can be *identified* with the operation of these particular memory processes or with the retrieval of a particular kind of information. Distinguishing between first- and second-order explanations of the relationship between conscious and non-conscious memory processing is therefore not only important for characterising the functional deficit in amnesia, but also provides genuinely telling evidence for addressing a less practical and more philosophical question, namely the relationship between conscious awareness and information processing.) According to a second-order account, amnesic patients should not show evidence on indirect tests of memory for *all* kinds of information that are available to explicit memory in control subjects, as the deficit in amnesia impairs the kind of memory processing accompanied by (or that can be identified with) conscious awareness of memory. Several authors provide second-order accounts, with amnesia resulting from damage to an episodic or declarative memory system, which can store information about the novel conjunctions of items after a single learning trial, with other systems that support repetition priming being intact (Cohen & Squire, 1980; Tulving, 1983; Weiskrantz, 1987).

The status of the priming of novel associations is pertinent to this distinction between first- and second-order accounts of the relationship between conscious awareness and memory. Such priming is predicted by a first-order account, in which there should be evidence from indirect tests of memory for all types of information that are also normally available to aware memory. Such priming is not predicted by a second-order account of the type described above, in which aware memory for entire processing episodes is mediated by a functionally and anatomically distinct system to that which underlies priming. The evidence suggests that amnesic patients do not show memory for the novel associations between items on indirect tests such as cued word-stem completion, when residual explicit memory is ruled out as a basis for responding, and that priming of novel associations in normal subjects depends upon the use of explicit memory processes; the experiments contained in this thesis are consistent with this view. There is therefore no support for a first-order explanation of the relationship between processing and awareness in memory, instead, the evidence is consistent with aware memory resulting from the operation of a specific episodic system that can be damaged independently of the perceptual representation system underlying item-specific repetition priming effects.

What we have, then, is a lack of good evidence for repetition priming of novel associations between items alongside reliable evidence for the priming of certain kinds of novel items themselves (novel objects and nonwords). Indeed, this pattern was apparent in Experiment 10. Within this single experiment, significant facilitation in the processing of novel objects was observed as a consequence of their repetition (primed items were responded to more quickly than unprimed items), but the priming effect was not sensitive to the pairings of items (responding to recombined different pairs was facilitated just as much as to pairs repeated intact). This dissociation between the kinds of novel information for which priming effects are evident is not contradictory; it can be explained by arguing that the locus of these repetition priming effects is a perceptual representation system. The novel objects used in Experiment 10, like the other kinds of novel visual stimuli for which priming effects have been demonstrated, have perceptual structure and can be represented in terms of structural descriptions. Schacter *et al.*'s (1990) finding that only structurally possible figures can be primed, and Dorfman's (1994) finding that only nonwords with familiar morphemic and syllabic structure can be primed are consistent with novel items being represented in terms of novel combinations of familiar sublexical and sub-object components. The novel associations between items are not, however, represented in the perceptual representation system; novel associations do not themselves have perceptual structure. Even when the pairings of items provide information necessary for the interpretation of the meaning of an item, as in the case of the homographs in Experiment 13, no evidence that the context in which stimuli occur plays a role in determining the repetition priming effect was obtained. The dissociation between priming of novel objects and lack of priming of novel associations can therefore be explained by the system underlying the effect's role in the representation of individual stimuli for the purposes of identification.

IS THERE ANY ROLE FOR PRE-EXISTING REPRESENTATIONS IN REPETITION PRIMING?

The fact that there can be repetition priming of novel objects and nonwords suggests a question: Is there *any* role for the activation of pre-existing representations in producing repetition priming? Findings of the priming of novel stimuli clearly rule out accounts that are phrased *solely* in terms of the activation of pre-existing representations (or strengthening of pre-existing connections) (Diamond & Rozin, 1984; Graf & Mandler, 1984; Morton, 1979). It does not follow, however, from the fact that repetition priming need not require pre-existing representations that activation of pre-existing representations *never* plays a role in producing the effect. Evidence such as Murrel and Morton's (1974) finding that a word will prime a morphologically related word (BORED primes BORING) but not a visually and phonologically similar unrelated word (BORED does not prime BORN) reveals that repetition priming can occur at the level of stored representations of root morphemes. There is no reason to predict this pattern of results on the basis of purely perceptual representations of the items.

It was suggested that early perceptual grouping processes, such as closure, proximity and continuation, resulted in the independent representation of the two novel objects simultaneously presented on each trial in Experiment 10. In the experiments with similar procedures to Experiment 10 that employed familiar stimuli (Experiments 1, 2, 3 and 6) these processes may also have resulted in the independent representation of the two items simultaneously displayed. In addition there may or may not have been some contribution to the item-specific priming effect from the activation of pre-existing representations. There is no way of knowing on the basis of these data, as the two possible reasons why stimuli are represented independently were confounded. One way to address this issue would be to manipulate the extent to which perceptual grouping processes can play a role in the independent representation of both familiar and novel items. This could be done by overlapping the two items presented simultaneously, and/or presenting them as open shapes or in fragmented form, in the training phase of the experiment. Such manipulations would be expected to differentially affect the effect on repetition priming of recombining the pairings of familiar and novel objects, if activation of pre-existing representations can play some role in producing priming. Two overlapping (or open, or somehow fragmented) familiar objects would still be recognised by subjects; stored item-specific representations of their identities would be activated as part of this recognition process, and this activation would result in the facilitated recognition of those same items when repeated - regardless of the pairings of the items. With unfamiliar objects, the two overlapping figures would be represented as being a single item. The display would be, to all intents and purposes, a single novel object. Recombining the pairings of items between training and test would then be expected to have a marked effect on the degree to which processing of stimulus pairs would be facilitated upon repetition. When repeated, a recombined pair (essentially a brand-new novel object) would not make contact with any item-specific representation created in the training phase.

This experiment describes, therefore, a way in which the logic of recombining the pairings of items between training and test, and the procedure used in Experiments 1, 2, 3, 6 and 10, can be adopted and adapted to examine the contribution of pre-existing representations in producing repetition priming. This issue is important for elaborating upon the nature of the item-specific representations underlying the priming effect; it is not central to the distinction between item-specific and episodic accounts of the effect. The experiments reported in this thesis provide no support for the latter class of accounts.

A finding of Schacter and his colleagues (Schacter *et al*, 1990; Schacter & Cooper, 1993) suggests another way in which the role of the activation of pre-existing representations in repetition priming can be examined, with reference to the work reported in this thesis. While priming effects were found by Schacter only for possible and not impossible figures, it was also the case that priming occurred for possible figures only after the encoding of "global shape information". The effect occurred following a left-right decision task (Schacter *et al.*, 1990), a function decision task (would the object make a better tool or support?), a store-put decision task (would the object be better to put things inside or store things on?), and a loud-soft decision task (what kind of noise would the object make?) (Schacter & Cooper, 1993). The effect did not occur following decisions about whether there were more horizontal or vertical lines in the figure, a task deemed not to require global shape encoding. This pattern of results suggests that the representation of novel objects in a manner sufficient to produce priming of those items when repeated may not occur in a completely mandatory fashion. In Experiment 11 reported here, where stimuli were familiar objects, it was argued that the priming effect did proceed via mandatory processes of object recognition. As performing the colour matching task at training primed subsequent identity matching decisions as much as did performing those same identity matching decisions at training, it was argued that representations of the identities of the stimuli were activated during the course of the colour matching task, even though access to these representations was not necessary to performing the colour matching task itself. Subjects could not help but recognise the familiar items. This poses a question as to whether, under the same conditions, subjects could not help but create representations of novel objects.

This question could be addressed by performing an experiment identical in design to Experiment 11, but in which stimuli were unfamiliar objects, such as were used in Experiment 10. If the representation of novel items requires attention to the global shape of the stimuli, as Schacter's studies suggest, then we might not expect as much priming of identity matching decisions following the colour matching task as following the same identity matching task, as the colour matching task requires attention only to local features of the objects (the small coloured section). If this were found to be the case, this result would reveal a difference in the properties of repetition priming of familiar and unfamiliar stimuli, revealing a role for the activation of pre-existing representations in producing the effect. Activation of pre-existing representations may occur in a mandatory fashion, while the creation of representations of novel items, capable of supporting repetition priming, may not.

The contribution of pre-existing knowledge to the representation of visual stimuli is an important topic in other areas of visual cognition research. There is evidence that selection of objects for action in vision can be object-based rather than spatially-based. For example Donnelly, Humphreys and Riddoch (1991) report, using a visual search task, that when elements in the display form a perceptual group then detection of a target item is unaffected by the number of elements present. When the elements do not cohere to form a perceptual whole, the number of elements present affects the time to detect the target. This object-based selection could occur because the elements in the first kind of display are grouped on the basis of early perceptual processes (as was suggested resulted in the independent representation of the novel objects in Experiment 10) or because elements in the display make contact with stored representations in memory, and top-down influence from these representations means that elements are grouped according to whether they are consistent with a given representation. Again, early grouping processes can be manipulated by presenting overlapping, open or fragmented pictures of objects simultaneously. If this manipulation was found to interact with whether the objects are familiar or novel on subjects' abilities to attend to the simultaneously presented objects (e.g. in reporting two features from a brief display, with either both features contained in one of the objects, or one feature contained in each, cf. Duncan, 1984), it would reveal a role for pre-existing knowledge in the representation of objects from a paradigm other than repetition priming. Such interactions between stimulus-based and memory-based grouping are predicted by certain recent models of visual attention (Farah, Wallace & Vecera, 1993; Humphreys & Riddoch, 1993).

AND ANOTHER LOCUS OF REPETITION PRIMING

While the results of the experiments contained in this thesis have all been consistent with a single locus of repetition priming (facilitated activation of perceptual representations used in stimulus recognition), these results should not be read as indicating that this is the *only* possible locus of the effect. In order to perform the same/different matching task employed here, subjects did not have to name the stimuli presented and, indeed, were unlikely to have done so given the speeded nature of the task, as retrieval of the names of objects is more time consuming than access to their semantic properties (Potter & Faulconer, 1975). In tasks that *do* require the naming of stimuli, there is good evidence that repetition priming can occur based on the facilitated activation of representations involved in name production, rather than stimulus identification. For example, Durso and Johnson (1979) found reliable priming of picture naming at test following reading of those object names aloud from their written forms in the training phase of the experiment. Similarly, Wheeldon and Monsell (1992) found priming of the time to name pictures of objects when those names had been read aloud or had been produced in response to a definition at training. The locus of the priming effect in these two studies could not have been that identified on the basis of the experiments reported here, as the pictures of the objects themselves did not appear in the training phase. Facilitation in naming resulted, rather, from the repetition of the spoken word form, this same form being produced in response to the words and definitions as to the pictures, revealing a locus of repetition priming to be in the processes of name production. Wheeldon and Monsell went on to show that producing a homophone of an object name did not prime naming of a picture of that object, so the locus of the effect could not be the activation of phonological forms themselves. They proposed that repetition priming resulted from changes in the connections between representations of meaning and spoken word form.

The recognition that there may be more than one source of facilitation in responding to stimuli as a function of their repetition, depending upon the precise task involved, allows certain data to be accounted for - data which have otherwise been taken as support for an episodic account of priming. While Durso and Johnson (1979) found priming of picture naming following reading of those names at training, they found a larger effect when the same pictures had been named at training. This pattern of results reflects the fact that facilitated name production produced the priming of picture naming following word naming, while facilitation of picture identification *and* name production produced the priming effect following picture naming. In the same vein, Logan (1990) reported a reduction in the degree of priming of pronunciation decisions to words following a change in task at training from pronunciation decisions to lexical decisions. Performing the pronunciation decision task at training would result in activation of both perceptual representations and representations employed in name production (or use of connections between representations employed in name production). Facilitation in the subsequent activation of representations at both of these loci would contribute to priming of pronunciation decisions at test. Performing the lexical decision task at training, however, would result in representations involved in stimulus identification, but not name production, being activated, and there would be only one source of facilitation in performing subsequent pronunciation decisions to those same items at test. Performing different tasks at training and test, rather than the same task, results, in these cases, to less priming being observed because of a change in the number of sources of facilitation in responding being available with different task demands. It is not necessary to conclude that the memory representations underlying the priming effect contain any information about the entire processing episode associated with each stimulus, such as the task-specific interpretation of the item, or the particular response made to that item. When a change in task to be performed does not introduce an additional contribution to priming from the facilitated retrieval of spoken word forms, no effect of the change is observed (Ellis *et al.*, 1990; Valentine *et al.*, 1993; Experiments 1 and 2 of this thesis).

IS REPETITION PRIMING EVER BASED ON THE RETRIEVAL OF PRIOR PROCESSING EPISODES?

The experiments reported in this thesis pose problems for an account of repetition priming based on the retrieval of prior processing episodes. The reasons for this have been discussed above. Episodic retrieval accounts and item-specific representation accounts are not mutually exclusive explanations however; the two mechanisms by which facilitation occurs in responding to stimuli as a function of their repetition could co-exist. By providing support for an item-specific account, it is not to deny that episodic priming may well occur under different conditions. These conditions are likely to be those under which retrieval of the products of prior processing provides a faster or more accurate basis for responding to stimuli than does responding to the stimuli afresh, so to speak. When subjects can perform the task quickly and accurately to unprimed items, they are less likely to use retrieval of prior processing episodes as a basis for responding. Wheeldon and Monsell (1992) provide an analogy that is useful in illustrating the way in which episodic retrieval may facilitate processing when more time consuming, or perhaps more demanding, tasks are being performed. If after having performed a tricky piece of mental arithmetic (53 × 17) one is asked to perform it again, it is likely that the sum would act as a retrieval cue for the products of the earlier processing - one would remember the answer given previously, rather than carrying out the entire calculation a second time. This analogy shows how episodic retrieval may be used to "take a short-cut" in producing a task-dependent response to a stimulus. It is then an empirical question whether this retrieval depends upon controlled or automatic processes in memory. So, for example, in the discussion of the cued word-stem completion task above and in Chapter 1, it was suggested that evidence for an episodic account includes evidence of a role for explicit, controlled memory processes in task performance, and not processes that dissociate from explicit memory. This need not always be the case.

The results of experiments which examine the effects of changes in surface form on repetition priming using written verbal stimuli are largely consistent with the view that episodic priming occurs when exceptional demands are placed on perceptual encoding mechanisms. Episodic accounts predict effects of changes in surface form on the magnitude of priming because the earliest perceptual processing provides the first cues to initiate retrieval of the prior processing episode; a change in surface form of an item, such as the font in which a word appears, should attenuate repetition effects. There appears to be an interaction between the extent to which such changes affect priming and the typicality or familiarity of the surface forms used. Larger effects occur when test items are in a less typical format, such as 3D ribbon-like typefaces (Jacoby & Hayman, 1987), or are inverted (Kolers, 1973, 1975) than when test surface forms are highly familiar to subjects. There is an asymmetry in transfer. With changes between two highly familiar surface forms, such as changes in case or between familiar fonts, repetition priming is not reliably attenuated (Carr *et al.*, 1989; Clarke & Morton, 1984; Levy & Kirsner, 1989; Rajaram & Roediger, 1993; Scarborough *et al.*, 1977). This seemingly mixed pattern of results can be explained once it is recognised that episodic and item-specific classes of account are not mutually exclusive; the recognition of stimuli with highly familiar surface forms proceeds via the activation of some abstract orthographic representation, whereas recognition of items with less typical surface forms benefits from the retrieval of representations of their prior processing to a degree greater than they make contact with abstract representations. There has been relatively little examination of whether this episodic retrieval is an effortful or an automatic memory process, although Kolers (1976) reported orientation-specific priming in the re-reading of text after one year, when subjects had no explicit memory for the materials. Brown and Carr (1993) report a dissociation between surface-form dependent repetition effects and explicit memory for the same materials, based on the manipulation of an experimental variable (whether items were words or nonwords). These result suggest that episodic priming effects need not be based on explicit memory for the repeated stimuli, in the right circumstances. A simple way to investigate this issue would be to examine surface-form specific priming of verbal stimuli in amnesic patients. A further and, as yet, unanswered question concerns whether surface-form specific repetition priming of words, when it is observed, reflects the retrieval of *entire* processing episodes, including information about decision processes and response selection and execution, or reflects the retrieval of only that perceptual information.

A similar pattern of results has been reported in a study of priming in the perceptual identification of visually presented objects. Srinivas (1993, Experiment 4) found only a very small difference in identification accuracy of typical views of objects when the same typical view or a different and unusual view was presented at training. When the unusual views were presented for identification at test, there was more priming when the same unusual view had been presented at training rather than the different and typical view of the object. These results were interpreted as indicating that subjects reconstructed the typical view from the unusual view during training, but not vice versa. Equally, these results are consistent with the possibility that subjects use the unusual views at test as a retrieval cue for the training phase identification of the stimuli, whereas such episodic retrieval would be more time consuming (and perhaps effortful) than identification of the usual views via the activation of their item-specific representations. The use of an accuracy measure rather than a response latency measure in this experiment masks any difference in the speed with which the two types of view were identified, and so does not allow direct examination of this hypothesis.

CONCLUSIONS

It is clear, as the results of the experiments reported in this thesis demonstrate, that an account based solely on the retrieval of entire prior processing episodes, or the reinstatement of prior processing demands, is untenable as an account of all repetition priming effects. The locus of the effect identified here is a pre-semantic system dedicated to the representation of perceptual structure and form for the purposes of the identification of individual stimuli. The effect need not depend on stored representations of the identities of individual known objects or words, but can be item-specific by virtue of perceptual grouping processes. A strong case can be made against views such as those of Jacoby and Brooks (1984) when claiming, "memory for episodes is not something that can only be searched after perception of a test item but, rather, memory for episodes contributes to the perceptual identification of the test item" (p. 507). I would not want to argue that accounts based on the retrieval of prior processing episodes, or the reinstatement of prior processing demands, have no place in our understanding of memory and perception, but rather that they are more appropriate to some memory phenomena than others. Performance on tests of recognition and recall cannot depend exclusively on the representations used for initial object or word identification. The context in which an item was seen, details of the task that was being performed and knowledge of other items that were also present are all available to the subject upon occasion, and are necessary to successful performance of such tasks. In a recognition memory test, for instance, one must be sensitive to whether an item was in the studied list, not merely whether it was recently seen. A correspondingly greater influence of overlap between training and test conditions might therefore be expected under such circumstances. The results of the experiments reported here place clear constraints, however, on the generality of such accounts. The results of these experiments are best interpreted in terms of one memory phenomenon - repetition priming - occurring within a pre-semantic perceptual representation system, or systems, dedicated to representing individual stimuli for the purposes of identification.

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APPENDICES

Appendix 1. *Sets of ten stimuli taken from Snodgrass & Vanderwart (1980, Appendix B), with mean (and standard deviation in brackets) percent name agreement, mean ratings of image agreement, familiarity, complexity and word frequency.*

	Set									
	a	b	c	d	e	f	g	h	i	j
	glove	harp	seal	spider	belt	skirt	button	ruler	fish	chair
	elephant	skunk	basket	stool	arm	glass	horse	dog	sledge	lamp
	zebra	telephone	strawberry	tree	cannon	snake	swing	lion	whistle	onion
	ear	flower	lightbulb	bottle	bell	cow	cup	iron	ladder	watch
	accordion	lobster	desk	hammer	sun	clown	toaster	nose	kite	scissors
	envelope	shirt	swan	tomato	pig	toothbrush	shoe	barrel	ball	helicopter
	fork	bowl	mountain	drum	pen	duck	squirrel	snowman	arrow	cap
	ring	frog	bus	rockingchair	flute	spoon	giraffe	bird	carrot	piano
	bear	hanger	umbrella	rabbit	pear	candle	screw	mushroom	wheel	pliers
	lemon	guitar	screwdriver	monkey	owl	grapes	comb	star	pipe	crown
%										
Name agreement	96 (4.6)	94 (5.3)	93 (5.3)	95 (4.9)	96 (5.0)	96 (3.0)	96 (2.8)	97 (3.9)	98 (2.7)	94 (4.9)
Image agreement	3.91 (0.49)	3.90 (0.46)	3.69 (0.57)	3.67 (0.53)	3.76 (0.51)	3.89 (0.43)	3.98 (0.46)	3.84 (0.42)	3.78 (0.76)	3.52 (0.59)
Familiarity	3.16 (1.11)	3.48 (1.08)	3.20 (1.04)	3.24 (0.71)	3.27 (1.30)	3.39 (1.01)	3.69 (0.85)	3.34 (0.88)	2.90 (0.47)	3.47 (0.95)
Complexity	3.12 (1.11)	3.35 (1.11)	3.15 (0.58)	3.06 (0.76)	2.76 (1.14)	2.93 (1.10)	3.05 (0.89)	2.76 (0.99)	2.44 (0.79)	2.93 (1.01)
Word Frequency	20.4 (19.0)	17.1 (23.6)	19.7 (21.3)	21.0 (26.9)	29.5 (39.9)	24.2 (29.3)	23.8 (35.6)	28.0 (25.2)	16.0 (17.9)	26.7 (27.6)

Ratings from Snodgrass & Vanderwart (1980). One factor analyses of variance revealed no reliable differences between any of the sets in any of the measures.

Appendix 2. *Experiment 1. Means and Standard Deviations of Test Phase Response Latencies (in Milliseconds), Percentage of Trials Excluded With Latencies Over 2000 msec and Percentage Error Rates.*

	Same Pairs		Different Pairs		
	Primed	Unprimed	Primed	Unprimed	Recombined
RT (msec)	**694**	**754**	**747**	**837**	**760**
sd	177	184	129	185	161
% RT>2000 msec	1.25	1.25	0.00	1.88	0.63
% Errors	1.27	1.27	0.00	1.27	2.52

Appendix 3. *Experiment 2. Means and Standard Deviations of Test Phase Response Latencies (in Milliseconds), Percentage of Trials Excluded With Latencies Over 2000 msec and Percentage Error Rates.*

	Same Pairs		Different Pairs		
	Primed	Unprimed	Primed	Unprimed	Recombined
RT (msec)	**649**	**718**	**737**	**808**	**741**
sd	139	147	149	153	154
% RT>2000 msec	1.25	0.00	0.00	1.88	0.00
% Errors	0.00	4.38	5.62	1.90	3.75

Appendix 4. *Experiment 3. Means and Standard Deviations of Test Phase Response Latencies (in Milliseconds), Percentage of Trials Excluded With Latencies Over 2000 msec and Percentage Error Rates.*

	Same Pairs		Different Pairs		
	Primed	Unprimed	Primed	Unprimed	Recombined
RT (msec)	**701**	**760**	**777**	**835**	**782**
sd	99	120	138	135	115
% RT>2000 msec	0.63	0.63	2.50	0.00	1.25
% Errors	1.26	8.80	1.90	2.50	0.63

Appendix 5. *Experiment 5. Means and Standard Deviations of Test Phase Response Latencies (in Milliseconds), Percentage of Trials Excluded With Latencies Over 2000 msec and Percentage Error Rates.*

	Same Pairs		Different Pairs		
	Primed	Unprimed	Primed	Unprimed	Reversed-form
RT (msec)	**616**	**680**	**705**	**756**	**763**
sd	107	132	91	104	133
% RT>2000 msec	0.00	0.00	0.63	0.00	0.00
% Errors	2.50	5.00	3.77	5.63	4.38

Appendix 6. *Experiment 6. Means and Standard Deviations of Test Phase Response Latencies (in Milliseconds), Percentage of Trials Excluded With Latencies Over 2000 msec and Percentage Error Rates.*

	Same Pairs		Different Pairs		
	Primed	Unprimed	Primed	Unprimed	Recombined
RT (msec)	**667**	**825**	**786**	**906**	**825**
sd	87	146	136	161	128
% RT>2000 msec	1.25	1.88	1.25	1.25	1.25
% Errors	5.06	7.01	2.53	3.80	1.90

Appendix 7. *Experiment 7. Means and Standard Deviations of Test Phase Response Latencies (in Milliseconds), Percentage of Trials Excluded With Latencies Over 2000 msec and Percentage Error Rates*

	Same Pairs		Different Pairs			
					Recombined-from	
	Primed	Unprimed	Primed	Unprimed	-different	-same
RT (msec)	**613**	**729**	**719**	**756**	**751**	**806**
sd	117	93	129	106	119	125
%RT>2000msec	0.00	1.25	1.88	0.00	0.00	0.00
% Errors	1.88	6.96	0.64	1.88	3.75	3.13

Appendix 8. *Experiment 8. Means and Standard Deviations of Test Phase Response Latencies (in Milliseconds), Percentage of Trials Excluded With Latencies Over 2000 msec and Percentage Error Rates.*

	Same Pairs		Different Pairs			
					Recombined-from	
	Primed	Unprimed	Primed	Unprimed	-different	-same
RT/msec	**620**	**708**	**755**	**802**	**771**	**800**
sd	86	115	139	141	139	108
%RT>2000msec	0.00	0.63	0.63	0.63	0.00	1.25
% Errors	3.75	3.77	2.52	0.63	1.88	1.90

Appendix 9. *Experiment 9. Means and Standard Deviations of Kucera-Francis (1967) Frequency Count Per Million and Word Length (Number of Letters) for Each Set of 10 Stimulus Items.*

Set	Frequency		Word length	
	Mean	sd	Mean	sd
a	35.2	34.7	3.6	0.7
b	39.7	31.3	4.3	1.0
c	39.2	36.4	4.1	0.7
d	36.3	42.0	3.8	0.8
e	39.4	40.3	4.5	1.2
f	39.4	38.0	4.3	0.8

Appendix 10. *Sets of Homographs with Associated Bias Words and Related Words Used in Experiment 9.*

Set	Homograph	Bias 1	Related word 1	Bias 2	Related word 2
a	band	concert	party	elastic	catapult
	fly	trouser	suit	insect	grub
	bow	knot	pulley	arrow	sign
	cross	temper	angry	nought	nothing
	eye	thread	bobbin	patch	repair
	nut	spanner	mechanic	squirrel	fur
	palm	wrist	cuff	coconut	shell
	bat	sport	referee	cave	pothole
	tank	jeep	army	heating	climate
	lace	shoe	pace	crochet	darn
b	bonnet	engine	power	easter	egg
	bar	cocktail	olive	gold	winner
	train	wedding	top-hat	rails	platform
	slide	photo	lens	seesaw	playground
	file	smooth	gentle	papers	crossword
	nail	hammer	toolbox	scissors	craft
	sink	dishes	drain	iceberg	polar
	fence	foil	oven	garden	allotment
	top	hoop	hopscotch	milk	cheese
	wave	farewell	voyage	surf	wetsuit
c	arms	weapons	battle	legs	running
	bowl	soup	spoon	wicket	umpire
	calf	baby	nappy	muscle	ache
	seal	wax	furniture	ocean	liner
	stamp	album	collection	tread	grip
	horn	tusk	rhinoceros	honk	blast
	jam	block	building	toast	breakfast
	lock	door	hinge	curl	rollers
	trunk	nose	perfume	luggage	holdall
	spade	hoe	soil	whist	poker
d	ball	round	circle	gown	robe
	bark	birch	silver	howl	wolf
	ear	noise	shout	harvest	bale
	fan	cheer	clap	cool	chill
	pen	pig	bacon	ink	blotter
	plane	pilot	driver	timber	sawdust
	ring	bell	clapper	diamond	ruby
	scales	flour	wheat	fin	gill
	bun	icing	sticky	hairgrip	perm
	bulb	filament	wire	bloom	petal

Appendix 10 continued. *Homographs Used in Different Pairs in Experiment 9.*

Set	Homograph
e	clipper
	dip
	trifle
	fast
	deck
	fair
	clog
	rake
	prune
	dart
f	bridge
	foul
	jar
	loop
	mouth
	stick
	pine
	pawn
	pump
	rose

Appendix 11. *Experiment 9. Means and Standard Deviations of Priming Test Phase Response Latencies (in Milliseconds), Percentage of Trials Excluded With Latencies Over 2000 msec and Percentage Error Rates.*

	Same Pairs			Different Pairs	
	Primed preserved interpretation	Primed changed interpretation	Unprimed	Primed	Unprimed
RT (msec)	**842**	**841**	**905**	**817**	**827**
sd	125	137	120	108	94
% RTs>2000 msec	1.88	3.13	1.88	0.00	0.00
% Errors	9.55	10.97	8.92	0.63	1.88

Appendix 12. *Means and Standard Deviations of Ratings on a Seven-Point Scale of Similarity to Real Objects for Each of 10 Sets of 10 Novel Objects Used in Experiment 10.* For 88 of the 100 items, these ratings are from Kroll & Potter (1984, Table A-1).

Set	Rating	
	Mean	sd
a	4.08	1.05
b	4.11	1.34
c	4.15	1.31
d	4.15	1.27
e	4.17	1.10
f	4.12	1.46
g	4.16	0.95
h	4.10	1.26
i	4.17	1.18
j	4.09	1.10

Subjects rated a novel object as "1" if it looked very much like a real object, and "7" if it looked nothing like a real object. Intermediate values were assigned to intermediate judgements.

Appendix 13. *Experiment 10. Means and Standard Deviations of Test Phase Response Latencies (in Milliseconds), Percentage of Trials Excluded With Latencies Over 2000 msec and Percentage Error Rates.*

	Same Pairs		Different Pairs		
	Primed	Unprimed	Primed	Unprimed	Recombined
RT (msec)	**905**	**1089**	**975**	**1057**	**977**
sd	182	283	186	218	189
% RT>2000 msec	4.38	8.75	5.63	6.25	5.00
% Errors	15.68	13.01	9.27	7.33	6.58

Appendix 14. *Experiment 11. Means and Standard Deviations of Test Phase Response Latencies (in Milliseconds), Percentage of Trials Excluded with Latencies Over 2000 msec and Percentage Error Rates*

Training task	Test task		Same Pairs		Different Pairs		Overall	
			Primed	Unprimed	Primed	Unprimed	Primed	Unprimed
Colour matching	Colour matching	RT (msec)	**1021**	**1055**	**1033**	**1037**	**1027**	**1046**
		sd	198	193	211	176	198	179
		% RT>2000 msec	2.5	1.9	1.9	9.4	2.2	5.6
		% Errors	2.6	0.6	0.0	2.1	1.3	1.4
Identity matching	Identity matching	RT (msec)	**817**	**923**	**881**	**1007**	**849**	**965**
		sd	150	178	172	192	160	184
		% RT>2000 msec	1.3	3.1	3.8	6.9	2.5	5.0
		% Errors	6.3	5.8	5.2	2.7	5.8	4.3
Colour matching	Identity matching	RT (msec)	**801**	**890**	**905**	**947**	**853**	**918**
		sd	121	152	157	163	146	155
		% RT>2000 msec	3.1	0.0	2.5	1.9	2.8	0.9
		% Errors	5.2	10.6	1.3	1.9	3.3	6.3