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Priming and Awareness

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ABSTRACT

Three sets of experiments were designed to test Marcel's (1983ab) claim that backward pattern masked word primes are processed automatically and without awareness to a level of representation where the meaning of the word is identified. In the first set of experiments, Marcel's critical SOA procedure for determining an awareness threshold was found to be unsatisfactory. There was no evidence for semantic priming effects when more trials were used to determine the critical SOA. In the second and third sets of experiments, awareness of backward pattern masked primes was determined by subject's report of the prime. Nonconscious priming effects from prior presentation of the target word in a lexical decision task, and the solution in an anagram solving task, were substantial and robust. Nonconscious semantic priming effects were small but were significant in both tasks when presentation was dichoptic. Nonconscious semantic priming effects in the anagram solving task were obtained under some conditions of binocular presentation. Priming effects are discussed with reference to word perception, reading, and theories of consciousness. One conclusion is that nonconscious automatic priming effects are "selective" and are far from being ubiquitous. This view of heterogeneous nonconscious selective priming does not support Marcel's (1983b) claim that nonconscious processing produces homogeneous activation to the highest level in all representations connected with the stimulus event.

CHAPTER ONE

Introduction

1.1 Perspective

In a recent critique of cognitive psychology, Dennett (1979) suggests that consciousness as a phenomenal experience has been largely ignored within cognitive theory:

> Cognitive psychologists have skirted the domain of consciousness by so wide a margin that they offer almost no suggestions about what the 'interface' between models of cognitive psychology and a theory of consciousness should be (p.201).

The frequent use of subject report as data in cognitive psychology indicates an assumption that inner representations equivalent to conscious experience exist. The role of consciousness in its relation to other aspects of behaviour should therefore be fundamental to theory. Dennett does not provide a theory of consciousness to rectify the "inadequacy", but suggests a broad distinction between those influences of which the individual is not conscious but which influence his or her behaviour, and those influences of which the person is conscious. If a computational metaphor is adopted, this may be characterised as two types of process. First, processes having only computational access (interacting subroutines operating over different nonconscious levels). Second, processes amenable to public access corresponding to the personal access to consciousness (subject to the capacity limitations imposed on this access). Dennett's suggestion for a dissociation between conscious and nonconscious processes has already been made explicit. The view of Helmholtz (1867), for example, was that consciousness was the result of "unconscious inferences":

> The psychic activities that lead us to infer that in front of us at a certain place there is a certain object of a certain character, are generally not conscious activities, but unconscious ones. In their result they are equivalent to a conclusion. (section 26)

Within information processing models many authors also endorse a functional distinction between conscious and nonconscious processes (Dixon, 1971, 1981; Shallice, 1972; Marcel, 1980, 1983b; Mandler, 1975; Posner and Snyder, 1975; Marcel and Patterson, 1978; Laberge, 1975; and Schiffrin and Schneider, 1977). This distinction is exemplified by the empirical evidence and theoretical position adopted by Marcel (1983a,b) to which particular attention will be given. Dixon (1971, 1981) and Marcel (1980, 1983b) use different terms to denote processes which are not conscious. Dixon uses the term "preconscious", which is misleading for it implies that processing is prior to awareness, or that such processes give rise to phenomenal representation. Many of the examples which he cites as evidence for this processing <u>never</u> produce awareness. Marcel's use of the term "unconscious" may be confused with the previous use of the term by Freud (1927) where it denotes a different meaning. In this thesis the term "nonconscious" is preferred as it implies greater inclusion than Dixon's "preconscious" and avoids the connotations associated with Marcel's use of "unconscious". "Nonconscious" includes (a) those processes subserving conscious experience and (b) processes providing high level representations which may affect behaviour but do not provide phenomenal representation.

The following sections discuss accounts of the functions of consciousness, and review some of the evidence for a dissociation between conscious and nonconscious processing. The argument is advanced that one way to identify the functions of consciousness is to determine the limits of processes involved only in nonconscious "computational" access. Comparison between what happens consciously, but not nonconsciously, may reflect some functions of conscious processes.

1.2. Consciousness and its functions

The terms "awareness" and "consciousness" will be used synonymously. Carr (1979) proposes that consciousness be described as "a changing body of introspectable mental activity" (p.123). Evidence for consciousness or awareness is often related to reportability. As Marcel (1983b) says:

> The primary criterion for consciousness is phenomenal awareness...Awareness is taken to be the prerequisite of an ability to acknowledge or 'comment upon' our percepts, thoughts, memories, and actions (p.240).

The distinction between conscious and nonconscious processes therefore is that the former are reportable whereas the latter are not.

The underlying assumption in this thesis is that consciousness has a function or functions and is not merely epiphenomenal. The view is similar to Rozin's (1976) who suggests that consciousness, as an emergent quality of brain, was positively selected. It provided the means for applying existing mental operations to new stimulus configurations, outside of the ecological niche that originally provided the basis for those mental operations. Individuals possessing this quality could operate more flexibly and survive under conditions where a more rigid, locally bound system was inadequate.

The opposite view is that consciousness is entirely epiphenomenal, is merely a consequence of brain activity, and an unavoidable trait within evolution. It need not have a function of its own, indeed it may only be something akin to transmission hum, merely a biproduct of the primary endeavour (fitness). A negative natural selection theory would hold that consciousness continues to exist because it bears no negative consequences for selection and would not be selected against. Consciousness in this latter schema bears no evolutionary significance and performs no functional role. Nothing is explained by consciousness that cannot be explained by referring to neural processes (Bechtel and Richardson, 1983). It follows that any effort expended on a psychological study of consciousness per se in an attempt to understand human behaviour could be put to better use.

The reappearance of consciousness in the psychological literature suggests a return to an investigation of its role in human behaviour. This is particularly noticeable within information processing models.

1.3. Consciousness in Information Processing Models.

A review of information processing approaches to consciousness presents a fragmented picture, where consciousness is attributed many different roles. Norman (1981), for example, asserts that it embraces a wide diversity of topics:

> Consciousness (includes) the issues of conscious and subconscious thought, the problem of awareness, attention, the control structures of cognition, the formation of intention (p.279).

One problem with such a broad definition is that it may lead to the confusing question which Norman later asks: "What - who - experiences the result of conscious attentional processes?" (p.280). This implies that the perceiver may be divorced from the processes involved in perception. According to Allport (1980) and Claxton (1980), both tautological reasoning and the unwitting invocation of homunculi are common in attempts to incorporate the concept of consciousness into information processing models. Examples of this are given in some of the theories discussed below. Developed theories of consciousness are not available although Carr (1979) suggests three approaches to consciousness within information processing models. One approach has been to adopt a computer program metaphor (Shallice, 1972). Others see consciousness as correlated with Working or Short-Term memory (Atkinson and Shiffrin, 1971; Mandler, 1975). A third view links consciousness with attention (James, 1890; Duncan, 1980). These approaches which address different aspects of the role of consciousness are not necessarily antithetical.

1.3.1. The Computer Program metaphor of Consciousness.

Shallice (1972) adopts a programming metaphor, for the planning or executive decision making role of consciousness. It is an approach specifically oriented towards action. Consciousness is thought of as an internal programming and control process, analogous to the decision programs in a complex time-sharing system. The function of consciousness is to set goals for action by prioritizing and executing the complex interaction of internal and external needs of the individual. Once goals are set by conscious operations they are effected by "automatic" processes. In the computer metaphor these are the machine-code subprograms where the output of operations (i.e., results of computations) are displayed in consciousness. These machine code subroutines are analogous to Allport's (1979, 1980) "production systems". Shallice (1972) extends the notion of machine code subroutines into a behavioural action system. The action system is activated on a unitary basis, using input from both sensory and motor sources, but the decision on which unit to select is the province of consciousness. Once a subroutine or action system is selected and put into operation it retains control of behaviour until consciousness transfers control to another system, or until the goal set by consciousness is accomplished. The notion of action systems as subroutines fits well with the acquisition of motor skills (Keele, 1968). A progressive acquisition of motor coordination enables higher levels of units to be compiled into machine code and relegated to automatic mode, enabling consciousness to operate on the next successively higher level of skill. Eventually the whole activity becomes one integrated, automatized, action system. Future calls for this system will require only the command to effect the operation, allowing consciousness to be available for further behavioural integration. In Shallice's (1972) view:

> The selector input selects which action system is to be dominant, sets the goal of the action system, and is itself preserved in memory. It

is suggested that this input corresponds to the concept of consciousness in the mental state sense of the word (p.390).

Shallice's model provides a useful perspective, but as he points out, it gives little help in understanding complex processes in visual perception: "nor have any aspects of consciousness such as the complexity of conscious perception been considered" (p.391).

1.3.2. Consciousness equated with Working or Short-Term Memory.

A second view of consciousness identifies it with Primary Memory (James, 1890) or Short Term Store (STS, Atkinson and Shiffrin, 1968, 1971; Erdelyi, 1974; Mandler, 1975). A limited amount of highly activated, easily accessible information, is held in this store in such a way that it can be juxtaposed with other items of information in that store. Atkinson and Shiffrin (1971) exemplify the approach:

> In our thinking we tend to equate (the) short term store with 'consciousness', that is, the thoughts and information of which we are currently aware can be considered part of the content of short term store (p.83).

Consciousness thus provides a sort of mental blackboard (Carr, 1979) where events in the psychological present can be extended before transfer to long term memory (LTM). However, Atkinson and Shiffrin imply later that "consciousness" should also include control processes: "Information and retrieval are best described in terms of the flow of information through the short term store and in the subject's control of that flow" (p.84, emphasis added). This view, which produces a divorce similar to that espoused by Norman, continues to be reiterated in the literature. Solso (1979), describing Atkinson and Shiffrin's model states that:

> "Information processing from one store to another is largely controlled by the subject. Information

briefly held in the sensory register is scanned by the subject and selected information is introduced into the short term store" (p.163, emphasis added).

It is difficult to understand what exactly his concept of "the subject" relates to within an information processing model. The appearance of "the subject" outside of the system which is supposed to represent his or her totality provides no real explanation of processes.

Mandler, (1975) views consciousness as "a state of a structure ...equivalent to focal attention" (p.238). However the clarity of definition is lost when he later suggests that:

> Practically all novel relations and orderings require that the events to be ordered must be simultaneously present in the conscious field... consciousness permits the comparison and inspection of various outcomes so that the choice systems can operate on these alternatives (p.241).

He emphasizes the important distinction between the contents of consciousness and the processes within consciousness (the choice systems) but the final position remains unclear. Does consciousness refer only to phenomenal representation (the blackboard) or does it refer to control processes, or both? Sperling (1967) was more specific. He identifies consciousness with the "scanner" which controls the sequencing and location for further information processing. Posner (1978) also links consciousness with control processes. He suggests that the concepts of attention, consciousness, and the general purpose limited capacity central processor (GPLCCP) all refer to the same entity: "conscious awareness is a direct event that plays a specific role within the stream of information processing". This "specific role" relates to control and organisation, particularly of unfamiliar tasks. Whether the concept of the GPLCCP itself represents a useful concept is questioned by Allport (1980) and defended by Hitch (1980).

The views outlined above which relate consciousness to primary memory, working memory, or short term store do not provide a coherent description of the role of consciousness. Most of them encounter difficulty in distinguishing between phenomenal representations, the processes involved in computing those representations, and the processes controlling those representations.

1.3.3. Consciousness equated with Attention

A third approach which relates consciousness to attention, also lacks coherence. James (1890) provided the basis for misunderstanding when he alluded to the close correspondence between consciousness and attention:

> We see that the mind is at every stage a theatre of possibilities. Selective consciousness consists in the comparison of these...the selection of some and the suppression of the rest.

Although there is a tendency to identify consciousness with some aspects of attention (Dixon, 1971; Posner and Snyder, 1975; Posner, 1978), many authors avoid a direct statement relating the two. As Allport (1980) points out, "the word (attention) is still used, by otherwise hard nosed information processing psychologists, as a code name for consciousness" (p.113). Consciousness, equated with attention, is a regulatory system which selects from amongst input provided both by sensory systems and internal memory retrieval operations in order to provide a contextually relevant response. Many theories posit two processes: (a) parallel analytical processes of relatively unlimited capacity which operate automatically prior to selection for (b) a limited capacity conscious attentional system. The locus (or loci; Erdelyi, 1974) for these limited capacity processes in selective attention is still unresolved (Allport, 1980; Duncan, 1980). An early locus for selection is implied where automatic "pre attentive processes" (Neisser, 1967) select from among competing stimuli solely on the basis of physical stimulus parameters. In "Early selection" theories conscious attention is a necessary prerequisite for access to the semantic system. Treisman and Gelade (1980), for example, suggest that analytical processes operate in parallel up to feature level. Conscious attention is necessary to conjoin or integrate the separate features into a discrete and meaningful object.

"Late selection" theorists also suggest a two process system (Deutsch and Deutsch, 1963; Norman, 1968; Duncan, 1980), but parallel processing includes establishing form and meaning as well as physical characteristics prior to the limited capacity attentional system. The role of consciousness (as attention) is to select between stimuli which have already been processed to semantic level. The controversy is still active although current evidence is substantially in favour of "Late selection" (Allport, 1977; Posner, 1978; Duncan, 1980; Marcel, 1983b). Evidence for late selection is provided by demonstrations of high level semantic analysis of unattended stimuli in dichotic listening studies (Corteen and Wood, 1972; Corteen and Dunn, 1974; Lewis, 1970, 1972). Similar evidence comes from some visual search studies which indicate preconscious categorisation (Carr and Bacharach, 1976; Duncan, 1980). More recently, there is evidence from pattern masking studies that automatic processing may continue to a level of meaning without the involvement of conscious attention. Several investigators claim that words which are pattern masked to prevent awareness may nonetheless provide semantic facilitation for targets in subsequent lexical decision and naming tasks (Marcel and Patterson, 1978; Marcel, 1980, 1983a; Fowler, Wolford, Slade, and Tassinary, 1981; de Groot, 1983; Carr, McCauley, Sperber, and Parmelee, 1982; Evett and Humphreys, 1981). One example of a Late selection theory is provided by Duncan (1980):

> The theory distinguishes two levels of perceptual representation. The work of stimulus identification and classification is performed at the first level, but outputs must pass through the limited capacity system to a second level before forming a reportable perception,

or in other words before reaching awareness (p.284).

In his theory meaning is derived at the first level but none of the information is available for response, or is in any part of awareness. However problems arise over the critical importance of the "selection schedule" for the limited capacity system. How are specific task demands interpreted at the level of selection to determine which stimuli are passed through the limited capacity system? Consciousness is equivalent to gaining second level representation, which implies that all operations below this level are nonconscious, and these include the mechanisms responsible for selection. Ultimately Duncan fails to account for this mechanism of selection. Duncan's view of consciousness, which minimizes conscious control processes compared with the major role played by nonconscious and automatic processes, is similar in this respect to Marcel's (1983b) view.

1.3.4. Marcel's (1983b) approach to consciousness

Marcel stresses the extent of nonconscious processing and the important functional distinction between conscious and nonconscious processes:

> All sensory data impinging however briefly upon receptors sensitive to them is analyzed, transformed, and redescribed, automatically and quite independently of consciousness, from its source form into every other representational form that the organism is capable of representing, whether by nature or acquisition (p.244).

Consciousness, according to Marcel is "an attempt to make sense of as much data as possible at the most functionally useful level" (p.238). Marcel's shares Posner and Boies (1971) view that consciousness represents a late stage in processing, and Mandler's (1975) view that consciousness is equated with focal attention. In Marcel's theory, consciousness plays an active role in perception "obtained by a constructive act of fitting a perceptual hypothesis to its sensory source" (p.245). Conscious representations are not automatically derived from nonconscious representations. The two levels of representation are qualitatively different and are neither "commensurate nor coextensive" (p.256). Each analytical stage of nonconscious processing produces two outputs: (a) a Result and (b) a Record. The Results support both information transfer within the system and nonconscious behaviour such as postural adjustments. Results also produce structural descriptions or "perceptual hypotheses" at each stage of analysis. An extended trace of the output, or Record, is produced at each stage, necessary in Marcel's theory for the process of recovery. Conscious experience occurs when a perceptual hypothesis, i.e. a Result of processing, is matched against a Record of processing. This functional and active view of consciousness is distinct from views where transfer from nonconscious processes to conscious awareness is automatically produced by the most highly activated nonconscious representation (Deutsch and Deutsch, 1963; Dixon, 1971). Consciousness is also responsible for structuring and synthesizing the information recovered from separate domains of processing. This is an important aspect of the theory, but how this is accomplished is left insufficiently specified.

There are further problems with Marcel's model. First, he states that "We choose at what level to be conscious" (p.247). This is an apparent tautology similar to those offered by Norman (1981) and Atkinson and Shiffrin (1968) above. Second, consciousness is described within two separate locations within the information flow: (a) fitting a hypothesis to its sensory source (record) and (b), synthesizing the output of all such hypotheses into a coherent unity. Third, if all stimuli are processed to their highest level of representation then there will be many equally competing verifiable hypotheses. Given that there is limited capacity at some point in the information flow, how does consciousness select task relevant from irrelevant information? Further difficulties with the model will be treated later in discussion of Marcel's empirical work.

1.3.5. Summary

A review of the literature does not provide a coherent account of consciousness, nor any real evidence for a precise function. Although the various approaches to consciousness in cognitive psychology differ in a number of details, they share some important common features. One theme running through all of them is the nonselective nature of nonconscious processes as contrasted with the highly selective nature of conscious processes. Nonconscious processes appear to apply in parallel and without capacity limitations to compute all possible representations up to whatever level nonconscious processes reach. They therefore stand in marked contrast to conceptions of "the unconscious" such as those developed within the psychoanalytic tradition. The conception of consciousness as being highly selective also stands in contrast to the richness of phenomenal experience. In most approaches selection is regarded as a conscious process, although debate continues on the locus of selection and the extent of automatic parallel processing. Duncan (1980, 1981) however, proposes that selection for consciousness is the result of a nonconscious selection procedure.

1.4. The Distinction between Automatic and Conscious Attentional Processes.

Many of the approaches outlined above have defined consciousness relative to nonconscious and automatic processes. Lexical decision, naming, and search tasks, using words and sometimes letters, have provided the main source of evidence for this distinction. The following review of the relative contributions of automatic and conscious attentional processes will be restricted to work in some of these areas. Posner and Snyder (1975) emphasize the distinction between the two types of processing:

> Automatic activation processes are those which may occur without intention, without any conscious awareness, and without interference with other mental activity. They are distinguished from operations performed by the conscious

processing system since the latter system is limited capacity and thus its commitment to any operation reduces its availability to perform any other function (p.81).

This distinction between automatic and conscious attentional processes is accepted by many authors (Neely, 1977; Laberge, 1975; Shiffrin and Schneider, 1977; Logan, 1980; Duncan, 1980; Marcel, 1980, 1983b; Fowler et al., 1981). Posner and Snyder propose that automatic processes have three characteristics, in that they operate (i) "without intention", (ii) "without awareness", and (iii) "without interference". However, there is evidence that these three components may describe different aspects of automaticity. For example, alphabetic encoding was thought to be an entirely automatic process (Keele, 1973; Shiffrin and Schneider, 1977). Paap and Ogden (1981), however, have provided results which suggest that two aspects of automaticity, "without intention" and "without interference", are discrete and separable in letter encoding. Letters which automatically activated their lexical representation (in a letter matching task) nonetheless utilised some limited capacity resources and interfered with the secondary task (probe RT). Paap and Ogden's conclusions, that the criteria of "without intention" and "without interference" should be dissociated as criteria for automaticity, have been supported by Regan (1981) and Kahneman and Chajczyk (1983). In Kahneman and Chajczyks experiment, the classic case of "automatic access" to the lexicon demonstrated by the Stroop task (Keele, 1972; Marcel, 1983a) was found to be liable to attentional interference and dilution.

Kahneman and Treisman (1983) suggest that the distinction between automatic and attentional processes may not be a simple one. They distinguish between processes which are "strongly automatic" and not liable to interference, and "partly automatic" processes which are. The involuntary reading of the colour word in the Stroop task (Kahneman and Chajczyk, 1983) may be regarded as only "partly automatic" within their definition.

The adoption of 'without conscious awareness' as an identifying criterion for automaticity (Posner and Snyder, 1975; Lucas and Bub, 1981;

Marcel, 1983b) is also problematic. Determining that a process is operating outside of awareness incurs the problems associated with subject introspection (Neisser, Hirst, and Spelke, 1981; Nisbett and Wilson, 1977; Evans, 1980a). Some of these problems will be discussed later. Marcel (1983b) attempts to link two of the criteria for automaticity ("without awareness" and "without interference") in claiming that "unconscious automatic processes are not bound by capacity" (p.252). In view of demonstrations that the "without intention" and "without interference" criteria for automaticity are conceptually and empirically independent (Paap and Ogden, 1981; Regan, 1981; Kahneman and Chajczyk, 1983) Marcel's claim may be premature.

Some authors have proposed that automatic processes may be distinguished from conscious attentional processes by the time onset of activation, and a lack of inhibitory effects (Neely, 1977; Fischler and Goodman, 1978; de Groot, 1983). These authors investigate the distinction between automatic and conscious attentional processes primarily within the lexical decision and naming tasks.

1.5. Automatic and Conscious Attentional processes in Lexical Decision and Naming Tasks

Meyer and Schvaneveldt's (1971) lexical decision task (LDT) experiments show that when subjects are asked to judge whether a letterstring is a word, the decision to a word is more rapid following a semantically related word than when following an unrelated word. They suggest that this facilitation is due to "semantic context". According to Schvaneveldt and Meyer (1973) an automatic spread of excitation (Collins and Loftus, 1975) proceeds from the node representing the first word of the pair to the node representing the second word. Subsequent access to these nodes requires less stimulus information, thereby providing facilitation. Posner and Snyder (1975), however, insist that priming effects are produced by conscious attentional processes as well as the automatic processes described by Schvaneveldt and Meyer (1973).

In an experiment designed to test the two models, Neely (1977) manipulated four variables: (a) whether the word target was an exemplar of either the category the subject expected (Expected) or a category the subject did not expect, (b) the semantic relatedness of prime and target (Related/Unrelated), (c) whether attention was directed to the prime category meaning (Nonshift) or a target category meaning (Shift), and (d), the SOA between prime and target (250, 400, 700, 2000 msec). Results showed that at 2000 msec SOA, Expected/Related targets were facilitated, but Expected/Unrelated targets were inhibited. As SOA decreased facilitation remained constant for Expected/Related targets but inhibition decreased for Expected/Unrelated targets, disappearing at 250 msec SOA. For Unexpected/Related targets there was inhibition at 2000 msec SOA which decreased with SOA until it became a facilitation effect at 250 msec SOA. From the pattern of inhibition and facilitation effects, Neely concludes that (i) fast-acting automatic processes produce an inhibitionless spread of activation which provide only facilitatory priming effects at 250 msec SOA, (ii) a slow acting conscious attentional component begins to affect processing at SOA's above 250 msec, producing inhibition for nonpredicted items. The conclusion that slow-acting conscious attentional processes also contribute to priming provides strong support for Posner and Snyder's (1975) two process model and is contrary to Schvaneveldt and Meyer's (1973) proposal that the semantic context effect is provided solely by automatic spreading activation. Work subsequent to Neely's experiments has developed in four main directions: (a) further examination of the time course of automatic processing, (b) the effect of different types of associative relationships, (c) the nature of conscious attentional effects such as "expectancy", and (d) the extent of nonconscious automatic processing.

1.5.1. The time course of automatic activation

In a LDT experiment Fischler and Goodman (1978) found that associative priming effects at 500 msec SOA disappeared when SOA was reduced to 90 msec. Although this finding supports Neely's results, evidence of semantic priming at 40 msec SOA in another of Fischler and Goodman's (1978) experiments points to a much earlier locus for some automatic facilitatory effects. However, if "automaticity" is determined by lack of inhibition, then measures of the time course of activation depend on the type of baseline used to determine relative facilitatory and inhibitory effects. For example, de Groot, Thomassen, and Hudson (1982) claim that Neely's method of using a row of X's as neutral prime inhibits processing of subsequent targets relative to the neutral prime "blank". The possibility that facilitation effects in Neely's experiment may have been overestimated and inhibition effects underestimated has been raised by de Groot et al.'s claim that inhibition effects may be demonstrated at 240 msec SOA when measured from the neutral "blank" baseline. De Groot (de Groot et al., 1982, de Groot, 1983) discusses the positive and negative aspects of different types of neutral baselines, concluding however: "All in all, we have no guarantee that a proper neutral condition will ever be achieved " (de Groot, 1983, p.422). The sensitivity of measures of inhibition and facilitation to the type of baseline adopted suggests that a precise locus for the onset of conscious attentional processes will be difficult to obtain. Nonetheless, most recent findings indicate that both automatic and conscious attentional processes contribute to the semantic context effect, and that automatic processes (determined by lack of inhibition) have a much faster rate of activation. For example, Warren's (1977) results indicate early automatic effects in a word naming task. The amount of semantic facilitation increased as prime-target SOA increased from 75 to 225 msec. In addition, Warren's results indicate that different types of semantic relationship (e.g., antonym, synonym) may produce differential temporal patterns in the time course of activation (and decay).

1.5.2. The effect of associative relationship on priming.

Several experiments indicate no difference in facilitation between category primes which are either high or low dominance exemplars of that category (Neely, 1977; Becker, 1980). Although Warren (1977) and Fischler (1977b) also found no effect of strength of association on amount of facilitation for associated word pairs, some authors demonstrate the opposite (Fischler and Goodman, 1978; de Groot, 1982, 1984). Becker (1980) suggests that these varied results may be explained by different patterns of facilitation dominance or inhibition dominance determined by the overall distribution and type of related words.

Priming by the same word (which will be called repetition priming) produces substantial facilitation (Scarborough, Cortese, and Scarborough, 1977), which is greater than semantic priming under the same conditions (Dannenbring and Briand, 1982). Furthermore, some forms of repetition priming are unaffected by words intervening between prime and target (Scarborough et al., 1977; Dannenbring and Briand, 1982) and may be longlasting, producing some facilitation even after a lapse of two days (Scarborough et al., 1977). The effect of intervening words on associative facilitation is inconclusive, although semantic effects are unlikely to survive more than one intervening item (Dannenberg and Briand, 1982; Davelaar and Coltheart, 1975). Differences between associative and repetition priming effects have important implications for spreading activation theories which will be discussed later.

1.5.3. The role of expectancy in priming

Associative facilitation in a lexical decision task (LDT) is "automatic" in that it occurs regardless of subject's expectancy (Fischler, 1977b; Tweedy, Lapinski, and Schvaneveldt, 1977). However, adaptive strategies based on expectancy can influence the size of the priming effect (Tweedy and Lapinski, 1981; Tweedy et al., 1977; de Groot, 1984). A comprehensive study by de Groot (1984) linked the combined effects of overall semantic context with the time course of priming. Four proportions of related items (0.25 - 1.0) and three SOA's (240; 540; 1040) were varied. Semantic priming was found for all combinations. The amount of priming varied with proportion for all SOA's, but varied with SOA only for high proportions. De Groot concludes that both results demonstrate a priming effect due to conscious attentional strategies based on expectancy. Neely (1977) suggested that expectancy leads subjects to adopt a "predict and match" strategy congruent with the overall semantic context. Facilitation may be due to reduction in the pool of possible matches (Forster, 1979), or due to changed activation thresholds in the logogen units consequent on attentional allocation (Morton, 1969; Neely, 1977). Several authors have also suggested a post-lexical mechanism where hypotheses about stimulus identity produced on a first pass through the system are checked against stimulus characteristics on subsequent passes (Schvaneveldt and McDonald, 1981; de Groot, 1982, 1984; Becker, 1980).

1.5.4. The role of Nonconscious automatic processes

Most of the foregoing studies have used the time onset of activation and lack of inhibitory effects to determine that a process is automatic rather than attentional. In an attempt to remove the conscious attentional component altogether, Posner and Snyder's (1975) suggestion that automatic processes can occur "without awareness" has been investigated. Recent studies using this criterion have reported that priming effects in a LDT are independent of conscious attentional processes (Marcel, 1980, 1983a; Fowler et al., 1981; Evett and Humphreys, 1981; Humphreys, Evett, and Taylor, 1983; Humphreys, Quinlan, and Evett, 1984; de Groot, 1983). Evidence has been obtained from a variety of experiments where the prime words have been masked to prevent awareness and consequently the use of conscious attentional strategies. Prime words masked so that subjects could not accurately detect their presence nevertheless produced associative facilitation for related targets (Marcel, 1980, 1983a; Fowler et al., 1981; Evett and Humphreys, 1981). In some cases facilitation from masked primes was equal to that produced when both prime and target were clearly visible (Marcel, 1983a; Fowler et al., 1981). Repetition of the prime had no effect on detection of the prime although it did increase the priming effect (Marcel, 1983a, Experiment 5). However, in at least one experiment there was no evidence of associative facilitation at an SOA of 200 msec (Fowler et al., 1981), a result difficult to explain given other evidence for early automatic activation (Neely, 1977; Warren, 1977; Fischler and Goodman, 1978).

Several other studies have demonstrated both word repetition and associative facilitation effects attributable to masked primes (Evett and Humphreys, 1981; Humphreys et al., 1983; de Groot, 1983). De Groot (1983) used a backward masking technique where determination of level of awareness depended on post experimental subject report. In this study associative facilitation was obtained for those subjects who were unaware of the prime, but it extended only to primes closely or directly related to the targets. Mediated primes ie. primes requiring two steps for a primary association, such as Bull - Milk, were not facilitated. De Groot claims that this finding has serious consequences for theories of automatic spreading activation. Evett and Humphreys (1981) used a four field masking paradigm (mask-prime-target-mask) which did not prevent prime identification on all occasions, although prime identification amounted to less than 2% of total trials. For those subjects who did not report seeing the prime, both repetition and associative priming effects were obtained, with greater facilitation for repetition priming. The repetition effects, independent of case, were attributed to both lexical and abstract graphemic priming. The abstract graphemic information appears to be derived from an automatic orthographic parsing procedure where level of facilitation effect is dependent on relative letter positions and number of common letters between prime and target (Humphreys, Quinlan, and Evett, 1984). However automatic phonological priming requires considerable phonological congruence between prime and target, and is dependent on lexical access (Evett and Humphreys, 1981; Humphreys et al., 1983). Carr, McCauley, Sperber, and Parmalee, (1982) have used a naming task to compare associated word and picture primes with word and picture targets. Under conditions where subjects were unable to identify the primes ("zero threshold" condition), there was no associative priming for related word targets, although both words and pictures provided associative facilitation for pictures.

The results of the above experiments investigating nonconscious automatic processing have major implications. First, the claim that the amount of associative facilitation is equal both with and without the contribution of conscious attentional processes (Marcel, 1983a; Fowler et al., 1981), suggests that consciousness is unimportant to some aspects of priming in the lexical decision task. The nature of the effect of conscious attentional processes on priming is still under dispute. Although Fischler (1977b) claims that associative priming effects are independent of expectancy, other authors claim that conscious attentional strategies can determine both the level (Tweedy and Lapinski, 1981; Tweedy et al., 1977; de Groot, 1984), and pattern of facilitation (Becker, 1980).

Second, as de Groot (1983) has pointed out, the finding that automatic associative facilitation spreads only to primary associates and no further, implies a considerable limitation on automatic spreading activation (Collins and Loftus, 1975). The notion of "spread" implies that activation from "Bull" would spread to "Cow" which in turn would activate "Milk". Failure to gain these results may be attributable to the specific stimulus set. On the other hand, the notion of spreading activation may be too simplistic in its present form. De Groot's (1983) result can be accommodated within either Posner and Snyder's (1975) theory or Morton's (1970) logogen model only if the assumption is made that activation decays as a function of "semantic distance".

Third, the level of facilitation afforded by nonconscious automatic processing appears to be dependent on the type of associative relationship between prime and target (Evett and Humphreys, 1981). In addition, neither

Posner and Snyder's nor Morton's model is able to predict the finding that decay of activation is nonlinear across different relationships between prime and target (Dannenberg and Briand, 1982; Scarborough et al., 1977). Differential effects produced by nonconscious automatic processes and dependent on stimulus characteristics suggests the possibility of automatic selection. Some aspects of this suggestion are explored later.

1.6. Criteria for claiming that stimuli are processed "without awareness"

Neisser, Hirst, and Spelke, (1981) claim that adopting the criterion of "without awareness" to determine automaticity involves using subject report and all the problems this entails (Nisbett and Wilson, 1977). Several of the authors above (Marcel, 1980, 1983a; Fowler et al., 1981) have attempted to overcome this problem by adopting a two-task method similar to the technique used in some of the subliminal perception experiments. In Marcel's (1983a) masked prime experiments, the first task was to determine a critical stimulus onset asynchrony (SOA) between prime and mask where subjects were unable to accurately detect whether a word or a blank field had been presented before the mask. The effect of the masked "subliminal" prime was then measured indirectly by performance on the second task, an LDT. However, claims of subliminal perception, or "perception without awareness", are still controversial (Merikle, 1982; Eriksen, 1960; Dixon, 1971, 1981; Diaper, Notes 1 and 2). Dixon (1971, 1981) provides extensive reviews of the subliminal perception literature and brings together considerable evidence in support of the view that nonconscious processing may extend to a lexical and semantic level. He acknowledges the problems involved in determining that a stimulus is processed without awareness and proposes three principle criteria for assessing subliminality. Three criteria are of particular relevance in determining whether stimuli have been processed "without awareness". In descending order of restrictiveness these are:

1. The eliciting of contingent responses by stimulation below the absolute awareness threshold, where this threshold is itself defined as the lowest level of stimulus energy at which the subject ever reports hearing (or seeing) anything of the stimulus (1971, p.12).

The procedure adopted by both Marcel (1983a, Experiments 3, 4, and 5) and Fowler et al. (1981, Experiments 4, 5, and 6) was intended to meet this criterion. Criticism of their procedure has centred on the technique for establishing the "threshold" for absolute awareness. First, the psychophysical methods used to establish the awareness threshold are often inadequate (Merikle, 1982; Eriksen, 1960; Diaper, Notes 1 and 2). Failure to use a sufficient number of presence-absence trials or to provide adequate instructions to subjects may produce measures which will not guarantee below-threshold performance on subsequent trials (Merikle, 1982; Diaper, Note 2). Second, as the number of observations are increased the performance on the detection task may improve, thus invalidating the concept of a fixed awareness threshold (Diaper, Notes 1 and 2). Diaper, in a two-task procedure, demonstrated that when the ratio of detection to nondetection trials is low, "subliminal" effects on a subsequent task can be obtained when the subject is performing at chance on the detection task. He argues however, that the detection task is insensitive under these conditions when compared to a task that uses a reaction time measure of performance. When only a small number of detection trials are used the critical SOA measure does not ensure that the subject is unable to detect on the subsequent task. Diaper claims that if the ratio of detection to nondetection trials is high then subliminal perception effects will not be found. Unfortunately there is no method for determining an appropriate ratio between detection and nondetection trials. Furthermore, it should be noted that detection performance may be better than chance even when the subject is phenomenally unaware of the presence of a stimulus. For example, the "blindsight" patient

A.B. (Weiskrantz, Warrington, Sanders, and Marshall, 1974) was able to detect the presence and location of stimuli presented in his "blind" hemifield with above chance accuracy, even though he was apparently unable to "see" the stimuli.

2. The retrospective reporting by the subject that he neither saw nor heard anything of the stimulus.

This second criterion is open to the further criticism that retrospective reporting confounds perceptual and memory factors, and is particularly susceptible to the effects of both subject strategy and demand characteristics (Orne, 1962a; Rosenthal, 1963). Dixon's second criterion varies in manner of application. For example, in some of the experiments which follow, retrospective reporting of the prime may be (a) pre-LDT trial, (b) post-LDT trial, or (c) post-experimental. The level and type of probe questions, and degree of post experimental debriefing are important in determining what the subject was aware of. It should be noted that these factors vary widely across different experiments. Evett and Humphreys (1981), for example, first set a threshold at which subjects could not accurately identify a prime. Post experimental questioning determined that subjects were able to identify primes on only a small proportion of trials. De Groot (1983), on the other hand, used a brief presentation of a masked prime with a high probability of report. After post experimental questioning subjects were allocated to "aware" or "unaware" treatment groups depending on whether or not they had been able to identify the prime. The results of the "unaware" group were considered to reflect nonconscious processing. The differences in criteria for determining awareness between the Marcel (1983a), Evett and Humphreys (1981), and de Groot (1983) procedures is substantial, and are important in interpreting or comparing their results.

3. The occurrence of contingent responses, without reported awareness of the stimulus, which differ qualitatively from those elicited by the same

stimulus when presented above the awareness threshold.

Dixon states that this criterion provides the strongest evidence for subliminal perception. Why qualitative differences in response to subliminal and supraliminal targets necessarily demonstrate subliminality is unclear. Marcel (1980) adopts this criterion to claim that the primes must have been subliminal. However this criterion is better seen as showing that there are other differences in internal processing that are associated with differences in awareness as indicated by detection criteria. If this were a definitional criterion then Marcel could not also claim that the primes in his (1983a) Experiment 4 were subliminal, as performance was the same under both mask and nomask conditions.

Marcel's (1983a) experiments, some of which were later replicated by Fowler et al. (1981), are central to this thesis. The experiment of particular interest (Experiment 4) uses a two-task paradigm, which, Marcel claims, demonstrates nonconscious priming under conditions which conform to Dixon's criterion 1. This experiment will be discussed in detail in the next section. However, an earlier experiment in the same series (Experiment 1), which has attracted a great deal of interest because of its theoretical importance, will be discussed first.

1.7. Marcel's (1983a) Experiments on Conscious and Nonconscious Perception

Marcel's experiments fall into two distinct methodological categories. In the first, the dependent variable was direct report of aspects of the masked word (Experiments 1 and 2). In the second, an indirect measure was taken of the effect of the masked word on a subsequent supraliminal target (Experiments 3, 4, and 5).

1.7.1. Experiments using a direct measure of processing.

In Experiment 1, binocular presentation of a word or blank field was followed by a pattern mask. The pattern mask was presented under conditions intended to produce central masking without producing peripheral masking

(Turvey, 1973). The SOA between target and mask was reduced until subjects began making errors in deciding whether or not a word had been presented (the starting SOA). Before each trial subjects were told that they were required (a) to say whether the stimulus was present or absent, (b) choose one of two choice alternatives which was most graphically similar to the masked word, or (c) choose one of two choice alternatives which was closest in meaning to the masked word. Six experimental SOA's of 5 msec intervals were tested, ranging from 5 msec above the starting SOA to 20 msec below. Results demonstrated that as SOA was reduced, subjects performance on the forced-choice decision fell to 60% correct first on presence-absence judgements, second on graphic similarity, and third, on semantic similarity. The results are particularly important to that aspect of Marcel's theory which deals with the processes of recovery for consciousness. His hypothesis is that the recovery of the records of perceptual analysis is accomplished in reverse order to the processes of perceptual analysis itself. This view is in contrast with most other models of reading; either the traditional notions of discrete stages of processing from visual analysis through graphic to semantic analysis (Rubenstein, Lewis and Rubenstein, 1971; Smith and Spoehr, 1974), or a cascade model such as McClelland's (1979). Furthermore, these experiments "provide perhaps the most substantial evidence" (Marcel 1983b, p.263) for the view of consciousness as an active process of recovery and synthesis. Experiment 1 attracted a great deal of interest and serious problems of validity have been exposed both by attempted replications and by criticisms of experiments using substantially the same methodology. These problems involve two main areas: (a) criticism of the method and (b) problems with replication.

(a) Criticisms of Method : Criticism centres on Marcel's procedure for presenting stimuli "without awareness". He asserts that at "that SOA at which subjects performance fell beneath 60% correct" (p.204) on a presence-absence discrimination task, subjects were not aware of the prime. The assertion that "semantic information was available when visual information was not" (p.206) depends entirely on this criterion. As a 60% performance level is, in absolute terms, greater than chance performance, this leaves the criterion open to question (Nolan and Carramazza, 1982; Fowler et al., 1981; Merikle, 1982). The number of trials to determine this criterion was also inadequate (Merikle, 1982; Diaper, Notes 1 and 2). Furthermore, no attempt was made to separate response criteria from sensitivity as could be done, for example, by using Signal Detection Theory (SDT) techniques. Similar criticisms have been made by Merikle (1982) against both Marcel's method and Fowler et al's (1981) replication.

Nolan and Caramazza (1982) point to a different problem in Marcel's method. There were 120 trials at each of the six SOA's, (40 for each of the three decisions), amounting to 720 trials overall. As there were only 240 words in the stimulus set, half of which were used for the presence-absence condition, each subject must have received some of the words twice and other words at least three times. Repetition tends to decrease response latency (Keele, 1969) and as Marcel (1983a, Experiment 5) has shown, repetition of a masked word increases the effect of semantic association. These observations led Nolan and Caramazza to conclude that the effect of repetition on the different judgements was unequal, providing a further source of artifact in the experiment.

Fowler et al. (1981), provided two convincing replications of Marcel's Experiment 1, but then proceeded to demonstrate that their own results were artifactual. In Marcel's Experiment 1, subjects had to make a forced choice decision on which of two probe words were similar either (a) graphically or (b) semantically, to the masked word. In a control "nonexperiment" (Fowler et al., 1981, Experiment 3), subjects were asked to rate the choice alternatives on the basis of which alternative "had more words like it" on the same criteria (graphic or semantic similarity). "Correct" alternatives were chosen more often for semantic than graphemic pairs, even though the test words were not presented. The pattern of results for the control experiment was essentially the same as those in their earlier experiments (and Marcel's original experiment). Fowler et al. conclude that effects attributable to the masked word in the earlier experiments are more parsimoniously explained by guessing strategies.

In a similar experiment derived from Marcel's Experiment 1, Allport (1977) found that a small proportion of report errors to backward masked target words, while graphically dissimilar to the target, were semantically related to it. His assumption that the 6% - 9% of semantically related words was significantly greater than chance, and thus providing evidence for nonconscious semantic access, has since been challenged by Ellis and Marshall (1978). They estimated that a similar percentage of semantically related words would be obtained from a random ordering of pairs, weakening Allport's claim for nonconscious semantic access. Williams and Parkin (1980) suggested that the effects could also be accounted for by guessing strategies derived from the knowledge that the experimental word set consisted solely of concrete nouns. The effect of guessing strategies is equally important in evaluating Marcel's claims, as the results of Fowler et al.'s nonexperiment demonstrates.

(b) Problems with Replication : Two failures to replicate Marcel's (1983a) Experiment 1 have been reported (Nolan and Caramazza, 1982; Forster and Creighton, Note 3), and the results of a successful replication have been more parsimoniously attributed to alternative hypotheses (Fowler et al., 1981). Nolan and Caramazza (1982) found no evidence that either semantic or graphic information was available when the subject was unable to detect the presence of the word. There was also no evidence that semantic information was available when graphic information was not. In Forster and Creighton's failure to replicate, backward masked words were presented dichoptically. Thresholds for different criterial judgements were measured by a sensitive up-down procedure for setting the target-mask SOA. They found a number of different thresholds ranging between identification and detection. In their experiment the threshold where decisions on semantic similarity fell to chance, while being equal to that of graphic decisions, was significantly higher than the point where detection was at chance. This result does not support the findings reported by Marcel.

One overall criticism of Marcel's direct report experiments is the use of direct report itself. Subjects were requested to make graphic or semantic comparisons based on words which they thought they could not see. This unusual request led to three refusals to continue and to the adoption of possibly abnormal strategies by four other subjects who were trying to comply. Experiment 1 has been discussed in some detail for two reasons. First, the notion that the recovery of records for conscious representation occurs in reverse order to the sequence of information processing, was based on this experiment. The criticisms above imply that the experiment does not sufficiently support such conclusions. Second, the criticisms also cast doubt on Marcel's claim that Experiment 1 provides strong evidence for a dissociation between conscious and nonconscious processes.

1.7.2. Experiments adopting an indirect measure of processing.

In Marcel's (1983a) Experiments 4 and 5, nonconscious information was indirectly determined by the effect of a masked word on a subsequent lexical decision response. The existence of nonconscious information was determined by the presence of semantic priming between associated word pairs, one of which was backward pattern masked in order to prevent awareness. Experiment 4 is critical to Marcel's theory as he claims that it provides "The reason for the necessity of the sensory record for consciousness" (Marcel, 1980, p.427). Dichoptic presentation ensured that any masking which occurred was central (Turvey, 1973). This experiment was the starting point for the following work, and it will be examined in some detail.

There were three conditions: (a) suprathreshold, (b) noise masking, and (c) backward pattern masking. Only the latter condition will be discussed in detail as it is the only one which is claimed to demonstrate priming without awareness. In common with Experiment 1, a two part procedure was used. In the first part the critical SOA was determined using a modified descending staircase technique. Once subjects began making detection errors, 40 further SOA trials were used to push down the SOA until subjects performed at no better than 60% correct. This "critical SOA" value was used without further reduction throughout the experimental trials. In part two Marcel adopted stimuli and procedure similar to Meyer and Schvaneveldt (1971). Two letterstrings were presented in succession where the subject's task was to provide a speeded manual response to the second letterstring (target) on the decision of whether it was a word or a nonword. Meyer and Schvaneveldt found that where the letterstrings were words, and where the target was semantically related to the first word, reaction times on the lexical decision were significantly faster than when the two words in the pair were semantically unrelated. Marcel replicates this finding in the suprathreshold condition. Response times for semantically related word targets were 62 msec faster than those to unrelated targets. When the prime was dichoptically backward pattern masked facilitation was 56 msec. On the basis of these results Marcel argues that backward pattern masking under specified conditions does not prevent further processing of the masked word. It only interferes with those processes which are responsible for phenomenal representation.

Fowler et al.'s (1981) replication of this experiment provided the same pattern of results but with considerably reduced effects. In their experiment semantic priming in the pattern masking condition was only 29 msec. When the prime-target SOA was reduced from 2000 msec to 200 msec there was no evidence of semantic priming. A comparable experiment by Carr et al. (1982) failed to demonstrate any evidence of nonconscious semantic priming on word naming latency. Word targets preceded by a related prime word were responded to <u>slower</u> than those preceded by unrelated primes.

Marcel claims that the technique for choosing the critical SOA produces a situation where subjects <u>could not have been conscious</u> of the prime in the LDT. The validity of this claim is of paramount importance, and a close critical examination of the method involved is necessary. Marcel's procedure for the critical SOA setting, was as follows. The subject was presented with a display of a word or a blank card for 10 msec followed by a dark field for a variable duration and finally by the mask for 20 msec. Subjects were told that on half the trials there would be a word and that on the other half there would be a blank space. They were required to make a decision on whether there was a blank or a stimulus before the mask. The objective was to reduce the SOA until the subject was at chance level on the presence-absence decision. A total of 40 trials (8 blocks of 5) were used to establish the critical SOA. This was determined as the value at which the subject could not perform at better than 60% correct, that is, 3 out of 5 correct. The procedure commenced by adopting a long SOA (100 msec) and reducing this until the subject started making errors. At this point the "steps" in the staircase were made smaller, continuing over the 40 trials until the critical value was reached. This method - "hunting" or "modified descending staircase" was a crude method of measuring a psychophysical threshold. It relied heavily on a few observations over a short period of time to establish a threshold which, it was assumed, would remain stable during the experimental series of 126 LDT trials which followed. The presence-absence task was considered difficult by most subjects, especially towards the end of the series of trials. When subjects were approaching the "3 out of 5" criterion on a forced choice presence-absence decision they were rarely confident of their judgements.

Marcel's claim is that as subjects were unable to perform above 3 out of 5 on the presence-absence trials, they could not be aware of any aspect of the prime throughout the LDT trials. Furthermore he asserts that the procedure satisfies Dixon's (1971) first criterion for establishing subliminal perception. The following chapter (i) investigates conditions under which nonconscious priming effects occur, and (ii) investigates the claim that these effects occur without awareness.

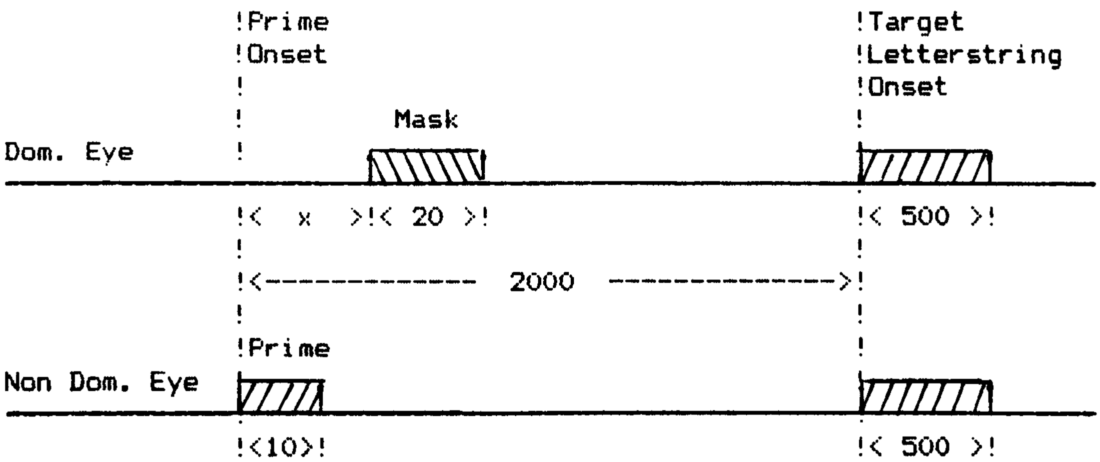
CHAPTER TWO

Priming without Awareness and Marcel's Critical SOA technique

The first objective of the research reported in this thesis was to replicate Marcel's (1983a) Experiment 4, and then to use the paradigm to further explore perception without awareness. The apparent simplicity of Marcel's procedure obscured several problems, particularly in the procedure for determining the critical SOA.

2.1. Pilot Studies

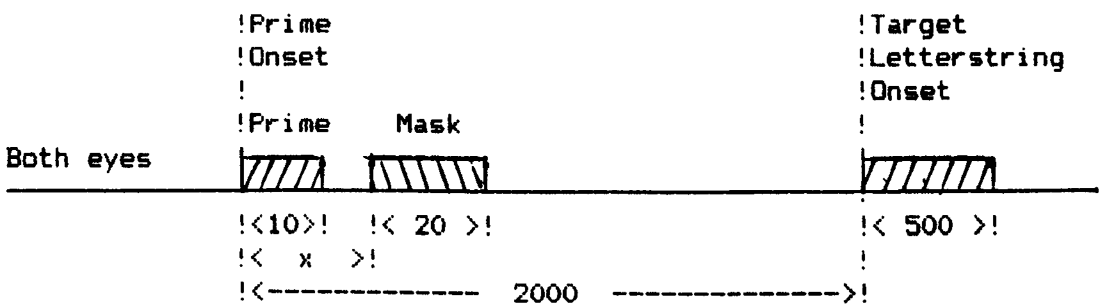
Preliminary experiments were designed to establish a comparable experimental situation. Eighteen first year psychology undergraduates took part in both structured and informal tests. An Electronics Development three field tachistoscope was adapted for dichoptic presentation. The general procedure was similar to that described by Marcel (1983a, Experiment 4) for dichoptic backward pattern masking (see Section 1.7.2). The stimulus presentation sequence is represented in Figure 1(a). Binocular presentation of the same stimulus set was also investigated. The general procedure for this condition was similar to that described by Marcel (1980, 1983a) for binocular presentation. The stimulus presentation sequence is represented in Figure 1(b). Twenty high frequency concrete nouns were used as primes in the presence-absence detection task. Two broad classes of problems were encountered: (a) those involving the relationship between prime and mask, and (b) the number of presence-absence trials to criterion.



x = Critical SOA (msec)

Figure 1(a)

Presentation sequence for dichoptic presentation (time in msec)



x = Critical SOA (msec)

Figure 1(b)

Presentation sequence for binocular presentation (time in msec)

2.1.1. The relationship between Prime and Mask.

There is no precise formula for the construction of a pattern mask relative to a particular target. Slight differences between target or mask characteristics, or in energy relations can alter the outcome of otherwise similar experiments (Kinsbourne and Warrington, 1962b; Turvey, 1973). Early informal experimentation varying the constitution and density of different masks became extremely time consuming, so a mask based on a replica of Marcel's was constructed. The mask used in the following experiments was larger in proportion to the primes than that used by Marcel. In later experiments a red cross appeared in the centre of the mask to provide a fixation point. The background luminance for the mask field was reported as 16 ft lamberts in Marcel's experiment. This experimenter was unable to achieve 16 ft lamberts for any field on the same model of tachistoscope (recently reconditioned) with the polaroid filters in place. The maximum background luminance obtained with polaroid filters was 14 ft lamberts (S.E.I. Spot photometer, cross-checked by a United Detector Technology 40X Opto-meter). The interaction between absolute and relative levels of luminance on pattern masking and nonconscious processing is unclear. Consequently, during informal studies, mask effectiveness was tested when luminance values were in the same ratio as Marcel's experiment.

2.1.2. Detection trials to criterion.

The critical SOA in Marcel's experiment was determined on the basis of the final block of eight blocks of five trials. In other words, this most important aspect of the experiment depended on a score of less than three out of five correct for only one block. The principal criticism of Marcel's procedure at this point was that both the number of steps and the number trials to assess the critical SOA was inadequate. During informal testing 40 presence-absence trials were found to be insufficient to determine a stable threshold. On some occasions the subject's presence-absence performance improved over further trials at the critical SOA. One subject, for example, who reached criterion at 30 msec SOA after eight blocks (40 trials) was able to identify the masked word at that SOA after 100 trials. The way in which this subject became aware of the stimulus is important. Apparently the prime did not appear gradually over trials, first as a blur, then as letters, then as an unidentified word and finally as an identified word. Instead it suddenly and completely appeared to the subject as a clearly identifiable word. When the number of trials to criterion was increased to 100 a more stable threshold was obtained. Consequently, ten blocks of ten trials were used in the SOA determination in the present experiments, using the same 60%

criterion as Marcel. The final (critical) block was always repeated once, where the second block at this value was scored independently. The increase in detection trials to criterion reduces but does not remove the problems later reported by both Merikle (1982) and Diaper (Notes 1 and 2). Although Marcel's 60% criterion is greater than the 50% "chance" criterion normally adopted for a two alternative forced choice decision, the 60% criterion was retained for the present experiments in order to facilitate replication of Marcel's original results.

One consequence of the increase in detection trials was a difficulty in achieving effective dichoptic masking above 10 msec SOA (ie 0 msec ISI). Many subjects could identify the prime word at 10 msec SOA under these conditions. Note that the mask, size and font of the primes, prime-mask luminance ratio, mode of presentation, and apparatus were all similar to those used by Marcel. Reducing the duration of the prime increased effective masking, but the 10 msec exposure duration was found to be only just sufficient to ensure 100% accurate identification without masking. Any reduction in the amount of information available at this point would reduce the chance that sufficient stimulus energy remained to allow nonconscious processes to operate.

Two methods were found which overcame these problems. First, binocular presentation increased the critical SOA for all subjects, but also allowed the possibility of peripheral masking (Turvey, 1973). Second, dichoptic masking was more effective and SOA's correspondingly longer when the size of the prime (and corresponding mask) was reduced. The results of the pilot studies demonstrate that a close replication of Marcel's Experiment 4 was not possible. However comparable experiments were designed, utilizing the same general approach as Marcel, i.e., a Critical SOA technique to determine lack of awareness of primes prior to a lexical decision task.

The following three experiments were conceived as a series. Each of the experiments differs from Marcel's Experiment 4 in various ways. These differences will be more fully described in the introduction to the experiments. The general strategy was to maximize nonconscious priming effects using repetition priming, and then to test for associative priming under the same experimental conditions. Repetition priming by unmasked primes was known to produce greater facilitation than that produced by associative priming (Scarborough et al., 1977; Meyer and Schvaneveldt, 1971; Marcel, Note 4). A stimulus set of associated word pairs was compiled which is fully described in Experiment 3. In Experiments 1 and 2 the target words from these associated pairs were used as the primes for repetition priming.

2.2. Experiment 1: Repetition priming in a dichoptic LDT.

2.2.1. Introduction

Repetition priming was examined in order to maximise the probability of a nonconscious priming effect. A single presentation of the target word was used as its own prime in the following experiment. The small stimuli, known to allow effective masking, were presented dichoptically. This ensured that masking was central (Turvey, 1973). The main differences between this experiment and Marcel's are (i) smaller stimuli, (ii) letterstrings were printed in upper case rather than lower case, (iii) only word primes were used (Marcel used both words and nonwords), (iv) 100 presence-absence detection judgements were used to determine the critical SOA instead of 40, (v) repetition priming was tested rather than associative priming, (vi) overall luminance levels were slightly lower.

2.2.2. Method

(i) Subjects

Six male and six female first year psychology students, aged between 17 and 21 (mean age 19), participated as part fulfillment of course requirements. Subjects were tested for visual acuity using a 'Lizars' eyesight test card. Only those subjects with 6/6 vision were accepted for the experiment.

(ii) Apparatus

An Electronics Development Three Field Tachistoscope was adapted for dichoptic presentation. Polaroid filters were inserted across two of the fields within the apparatus. An external slide arrangement between the viewing hood and the machine body allowed the two sets of filters to be either crossed or uncrossed. Field luminance intensities were fixed at a level which, on the basis of findings of the previous experiments, would maximise masking under these conditions. Luminance of (a) the mask field was 7 ft lamberts, and (b) both the prime and target fields was 4.5 ft lamberts. The response board consisted of three response buttons 3.3 in. apart arranged in an inverted triangle. The lower button was marked "START" with the other two marked "YES" and "NO". The "YES" response button was always to the subject's dominant hand, and both response buttons were connected to a "Forth Electronics" millisecond timer.

(iii) Stimuli

The stimulus set consisted of 80 pairs of four-character letterstrings. The first member of the pair (the prime) was always a word. Half of the targets were words and half were nonwords. Target word frequency was between 10 and 872 with a mean freqency of 98 per million (Kucera and Francis, 1967). Nonwords were constructed by selecting four letter words of similar frequency and changing one consonant. There were two word lists, A and B, such that repetition targets in List A were unrelated targets in List B. Half of the subjects received each list. The list of words and nonwords used in experimental trials is given in Appendix A.1.

All stimuli were drawn in the centre of white 6 in. by 4 in. cards using 10 pt. Helvetica Light Letraset. All letters were capitals. Maximum letter size was 0.1 in. by 0.1 in. (0.3 degrees visual angle). Letterstrings measured 0.4 in. wide by 0.1 in. high, subtending a horizontal visual angle of 1.2 degrees and vertical angle of 0.3 degrees when viewed in the tachistoscope. The pattern mask was constructed using broken letters of the same Letraset typeface as the words, arranged in different orientations to give a uniform and approximately equal black : white ratio. The mask measured 2.3 in. by 1.2 in., subtending a horizontal angle of 6.5 degrees and a vertical angle of 3.4 degrees.

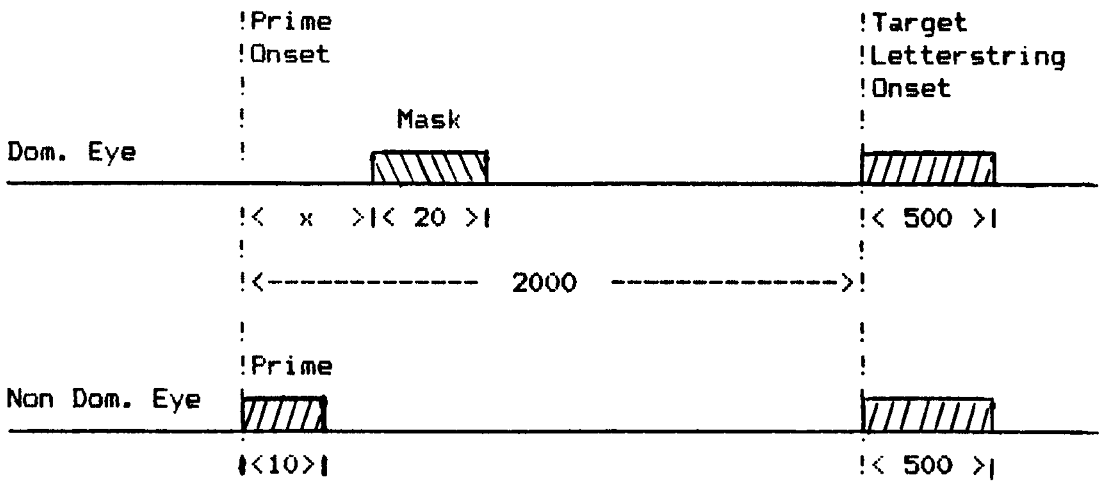
(iv) Procedure.

Subjects were tested for eye dominance and then randomly allocated to condition: either (a) Mask condition first or (b) Nomask first. In the eye dominance test, the subject stood at three metres from the scale and was asked to point at the centre line with a pencil. Closing first one eye then the other the subject reported the apparent movement of the pointer on the scale. The test was repeated three times and the score was averaged. The dominant eye was assumed to be the one where closure elicited the greatest amount of apparent movement on the scale. In cases where the score was equal for both eyes the subject was assessed as having no dominance, and in these cases the mask field was presented to the eye ipsilateral with hand dominance.

(a) Mask condition: (i) the critical SOA.

As this is an important part of the experiment it will be described more fully at this point. All experiments in this series utilising a critical SOA follow the same general procedure. The presentation sequence is shown in Figure 2.

Subjects were seated at the apparatus and were told that they would be receiving stimuli presented to each eye separately. Subjects were told that they would be given a series of trials where a word or a blank would be presented followed by a mask, and that on half the trials there would be a blank and half the trials a word. The subjects task was to decide which was which, and to say "something" if there was a word and to state what they saw, or "nothing" if there was a blank. Subjects were told to take a blur or a dark patch as evidence for "something".



x = Critical SOA (msec

Figure 2

Presentation sequence for Mask condition in Experiment 1 (time in msec)

A word or blank white card was presented to the nondominant eye for 10 msec. This was followed by a dark field for a variable SOA. The pattern mask was then displayed to the dominant eye for 20 msec. The initial SOA was 100 msec. The SOA was progressively reduced using a "modified descending staircase method", where the size of the reduction (step) was determined by the subject's performance level. Reduction was in 10 msec steps until the subject began making errors on a correct decision of presence- absence. At this point the step was reduced to 5 msec, and then to 2 msec when the subject began approaching criterion. Ten blocks of 10 trials were used to determine the critical SOA (ie. the setting where the subject was responding at or below 60% correct).

(a) Mask condition: (ii) the Lexical Decision Task.

Subjects were read the instructions for the second part of the experiment (see Appendix A.2). In brief, the subjects were told that they would see some flashes and a mask followed by a letterstring. The task was to watch the presentation sequence closely and to respond as quickly as possible when the letterstring appeared on the basis of whether it was a word or a nonword. Subjects were shown five examples of nonwords as illustration, none of which were used in the experiment. The presentation sequence is shown in Figure 2. Subjects initiated each trial by pressing the "Start" button. A one second dark period was followed by a 10 msec display of the first letterstring (prime) to the non-dominant eye followed by a dark field for the predetermined SOA. A pattern mask was displayed to the dominant eye for 20 msec followed by a dark field for a second variable period. Finally a second letterstring (the target word) was presented to both eyes and remained on for 500 msec during which time the subject was expected to respond. The second variable period was calculated so that the prime-target SOA remained constant throughout the experiment at 2000 msec. Each subject received 20 practice LDT trials followed by 40 experimental trials. Stimuli for the practice trials were derived in the same manner as those for the experimental trials. At the end of the experimental trials the subject was given another series of 40 presence-absence trials to give a post-experimental critical SOA. Subjects were then asked how many words they had seen on each presentation and asked to describe the display sequence. They were specifically asked if they had seen more than one word on any trial, or if they had noticed anything peculiar during the experiment.

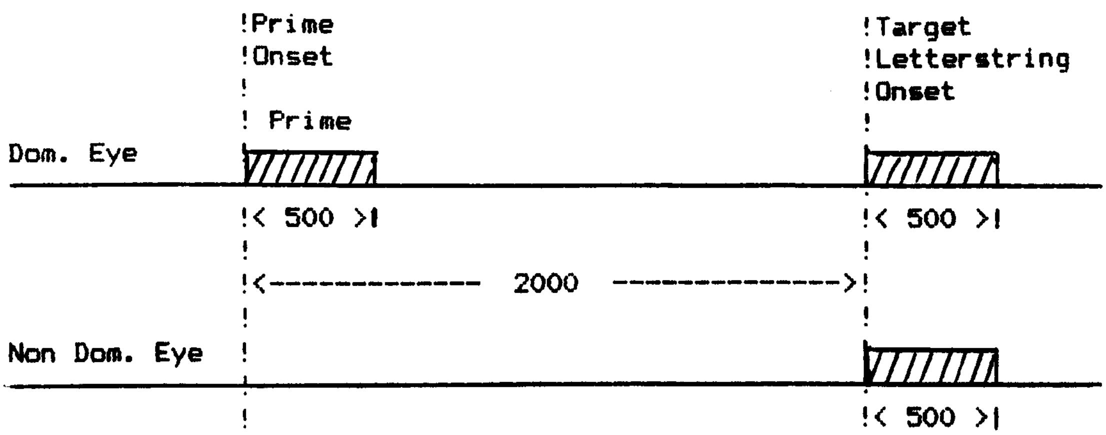


Figure 3

<u>Presentation sequence for Nomask condition in Experiment 1</u> (time in msec)

(b) Nomask condition: Lexical Decision Task

The presentation sequence, similar to that used by Marcel (1983a) and Fowler et al. (1981), is shown in Figure 3. Subjects initiated each trial by pressing the "Start" button. A one second dark period was followed by the first letterstring which was displayed for 500 msec. A dark period of 1500 msec before the second letterstring, (which was displayed for 500 msec), ensured a 2000 msec prime-target SOA. Subjects were asked to read the first letterstring but respond only to the second letterstring on the basis of whether it was a word or not ("Yes" or "No").

2.2.3. Results

Critical SOA's ranged from 10 to 90 msec (mean = 36 msec). There were no differences between pre- and post- experimental critical SOA values. Error rate was 1.9% for "Yes" responses and 3.0% for "No" responses.

Table 1

Mean RT's (msec) to Repetition and Unrelated primed targets in Experiment 1.

	"Yes" Responses		"No" Responses
	Repetition	Unrelated	
Masked	689	694	764
Not Masked	571	677	715

(i) A two way within subjects analysis of variance (ANOVA), with factors Masking (Mask, Nomask) and Response (Yes, No), demonstrates that both the effects of Masking (F (1,23) = 9.05, p < .01), and Response (F (1,23) = 48.79, p < .0001), are significant. Further analysis is of "Yes" responses only.

(ii) A two way within subjects ANOVA, with factors Masking (Mask, Nomask) and Prime Type (repetition, unrelated), demonstrates that both the main effects of Masking ($\underline{F}$ (1,11) = 7.36, $\underline{p}$ < .05), and Prime Type ($\underline{F}$ (1,11) = 24.70, $\underline{p}$ < .001), are significant. There is also a significant interaction between the two main effects ($\underline{F}$ (1,11) = 13.60, $\underline{p}$ <.01). Separate one way ANOVA's were performed for the Mask and Nomask conditions:

(a) In the Nomask condition the 106 msec faster response to repetition compared with unrelated targets is significant ($\underline{F}$ (1,11) = 36.05, $\underline{p}$ < .0001).

(b) In the Mask condition the 5 msec faster response to repetition compared with unrelated targets is not significant.

2.2.4. Discussion

(a) Criteria for awareness: The critical SOA measurements and post-experimental subject report imply that subjects were not aware of the prime word at any time during the course of the experiment. The lack of a difference between the critical SOA value pre- and post- lexical decision task suggests that subjects perceptual discrimination did not change during the course of the LDT trials. As presence-absence discrimination was at or below 60%, it is unlikely that subjects could have identified the words. The second measure, post experimental report is supportive. When questioned, all subjects reported that they were unaware that prime words had been presented.

(b) Priming effects

(i) In the Nomask condition the hypothesis that Repetition priming would produce a large priming effect is supported by the results. Repetition priming of 106 msec in this experiment is comparable to the 117 msec repetition priming in Scarborough et al.'s (1977) experiment. It is also considerably greater than associative priming by non-masked associated words in related experiments (Meyer and Schvaneveldt, 1971; Marcel, 1983a; Fowler et al., 1981). No direct comparison can be made between repetition and associative priming as there is no reason to suggest that lexical access has been achieved in the present experiment. In lexical decision tasks which demonstrate associative priming, lexical access must necessarily have occurred to produce such an effect. In this experiment facilitation could have been provided at any level within the information processing system from feature descriptions to the whole word lexicon.

(ii) In the Mask condition the stringent criteria for establishing lack of awareness allow strong claims that priming effects are attributable to nonconscious processes. However, the 5 msec priming effect was much less than when the prime was clearly visible. The results show that there are conditions where centrally masked words produce little or no priming. It is not the case therefore that automatic access to the lexicon is guaranteed by central masking, as Marcel would suggest.

The lack of significant nonconscious repetition priming is puzzling, but supports the general thesis (which will be described later), that nonconscious priming is "selective". As presentation is dichoptic, failure to achieve significant nonconscious priming effects cannot be accounted for by peripheral masking. Every effort had been made to ensure that priming would be maximised. If nonconscious processing is limited by physical properties of the stimulus such as size or spatial frequency, then the prime word in this experiment may be insufficient in these respects. However the size of the prime had already been determined as the largest that dichoptic masking would allow. Smaller words of higher spatial frequency may have contributed to a reduced effect, but it's hard to see how this could eradicate it altogether. Each subject had been able to identify a non-masked prime presented for 10 msec, which ensured that sufficient information was available for identification. It may be that a brief flash of such a small prime is insufficient to produce the activation necessary for nonconscious priming.

2.3. Experiment 2: Repetition Priming in a Binocular LDT

2.3.1. Introduction

If failure to produce priming in the mask condition in Experiment 1 is attributable to the small size of the letters used then increasing their size should produce priming. The pilot studies provided one condition which produced effective masking for large stimuli, but only under binocular presentation. The problem with binocular presentation is the risk that peripheral masking will eradicate any trace of processing (Turvey, 1973; Marcel, 1983a). Backward pattern masking with binocular presentation has, however, been reported to produce nonconscious priming under some conditions (Marcel, 1983a). The following experiment used the same word set as in Experiment 1, but presented in the same typeface, case and size as in Marcel Experiment 4. It differs from Marcel's experiment in that (i) presentation was binocular rather than dichoptic, (ii) 100 presence-absence detection trials were used to determine the Critical SOA, instead of than 40, (iii) repetition priming is investigated rather than associative priming, (iv) luminance levels were lower in the present experiment. The Nomask condition was omitted on the assumption that repetition priming would be as effective for binocularly presented, lower case stimuli as it had been for the same stimulus set dichoptically presented in upper case, where substantial priming was produced (Experiment 1).

2.3.2. Method

(i) Subjects

Seven male and five female first year psychology students, aged between 18 and 38 (mean age 25.8) participated as part fulfillment of course requirement. Subject testing and acceptance criteria were the same as for Experiment 1 (Section 2.2.2).

(ii) Apparatus

The Electronic Development Three Field tachistoscope described in Experiment 1 was used in this experiment. As dichoptic presentation was not required the polaroid filters were removed. The field luminances were set on the basis of the results of the earlier pilot studies. The luminance for all fields was 5 ft lamberts.

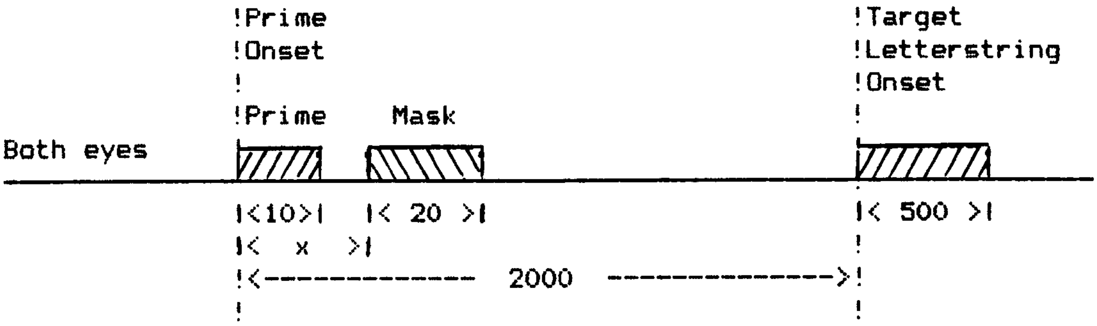
(iii) Stimuli

The words and nonwords were the same as for Experiment 1, except that they were printed in larger lower case letters.

All stimuli were drawn in the centre of white 6 in. by 4 in. cards using 16 pt. Helvetica Light Letraset. Maximum letter size was 0.1 in. wide by 0.2 in. high. Letterstrings measured 0.5 in. wide by 0.2 in. high, subtending a horizontal visual angle of 1.6 degrees and vertical angle of 0.6 degrees when viewed in the tachistiscope. The pattern mask was constructed using broken letters of the same Letraset typeface as the words, arranged in different orientations to give a uniform and approximately equal black : white ratio. The mask measured 2.5 in. by 0.5 in., subtending a horizontal angle of 7 degrees and a vertical angle of 1.5 degrees. A small cross illuminated from behind by a red LED provided a fixation mark in the centre of the mask slightly above the point of appearance for the stimuli.

(iv) Procedure.

Subjects were randomly allocated to Group A or Group B. Each Group was presented with the same target words. Repetition primes for Group A were Unrelated primes in Group B. In this experiment the Nomask condition was not included. As presentation was binocular the eye dominance measure was not required. With these exceptions the procedure was the same as in the Mask condition in Experiment 1. The presentation sequence is shown in Figure 4.



x = Critical SOA (msec)

Figure 4

Presentation sequence for Experiment 2 (time in msec)

2.3.3. Results

Table 2

Priming effects from pattern masked words in Experiment 2.

(Mean RT's in msec)

	"Yes" Responses		"No" Responses
	Repetition	Unrelated	
Masked	524	549	694

Critical SOA's ranged from 10 and 35 msec (mean = 16.7 msec). There were no differences between pre- and post- experimental critical SOA values. Error rate was 1.7% for "Yes" responses and 3.2% for "No" responses.

(i) A one way within subjects ANOVA shows that the RT difference between "Yes" and "No" responses is highly significant (F (1,23) = 104.07, p < .0001).

(ii) A one way within subjects ANOVA on the "Yes" responses alone demonstrates that the main effect of Prime Type (repetition, unrelated) is significant (F (1,11) = 6.21, p < .05).

2.3.4. Discussion

(a) Criteria for awareness

The two measures for lack of awareness (Critical SOA and post-experimental questioning) support the claim that subjects were not aware of the primes during the LDT trials. Backward pattern masking with binocular presentation provides effective masking under these experimental conditions. Priming effects obtained are therefore attributed to nonconscious processes.

(b) Priming effects

The results demonstrate that repetition priming can be obtained binocularly. The priming effect is far smaller than would have been expected from Marcel's results or those of Fowler et al. (1981). Associated priming from masked primes was greater in their experiments (56 msec and 29 msec respectively) than the 25 msec repetition effect in this experiment. It was argued earlier that repetition primes would provide greater facilitation than associated primes, a suggestion which was supported in part by the large Nomask priming effects in Experiment 1. The meagre priming here may be due in part to some contribution of peripheral masking (Turvey, 1973). Binocular presentation is liable to peripheral effects, which, according to Marcel's Experiment 4, would prevent further processing of the masked prime. The confounding of form and meaning in same-case repetition priming precludes any strong claims for the locus of priming effects. As in Experiment 1, facilitation could be provided at any or all levels within the information processing flow.

2.4. Experiment 3: Associative Priming in a Binocular LDT

2.4.1. Introduction

The results of Experiment 2 demonstrate that repetition priming can be obtained binocularly. The following experiment was designed to see if nonconscious associative priming can be obtained under the same conditions that elicits nonconscious repetition priming.

Experiment 3 follows essentially the same procedure as the previous two experiments. A set of associated word pairs intended to maximise associative priming was compiled. Marcel's word pairs were derived in the same manner and from the same source as in Meyer and Schvaneveldt (1971) i.e., from the Connecticut Free Association Norms (CFA Norms; Bousfield, Cohen, Whitmarsh, and Kincaid, 1961). The CFA Norms consist of associated pairs of words of varying word length, word frequency, word type, association type, and association strength. The selection of exactly the same stimuli was not possible from this description. The resulting decision on what stimuli to use was thus somewhat arbitrary.

A distinction can be drawn between word relationships based directly on shared semantic attributes and those based more on the predictive relationship between words, such as butterfly and net. The latter type of relationship is usually ascertained by free association techniques, but the two referents do not necessarily share common physical properties. The spreading activation theorists (e.g., Collins and Loftus, 1975) posit that following access to the representation of a particular word, activation spreads automatically through the paths of the memory network. Precisely how this network is organised is as yet uncharted, but it seems clear that the activation of the representation of the word BOAT should result in spreading activation to SHIP, one of its synonyms. Whether the consequent raised activation for SHIP would be greater than that for a non-synonym associate such as DOCK, providing more or less facilitation, depends on the structure of memory. Organisation on the basis of semantic similarity would provide greater activation for synonyms, whereas organisation on the basis of non-semantic association, or the probability of one word following another, would produce a lesser effect. Given that synonyms constitute a high proportion of the CFA norms, and that these norms had consistently provided stimulus pairs known to produce priming, the decision was made to select only synonym pairs for Experiment 3.

There are several differences between this experiment and Marcel's Experiment 4, (i) presentation is binocular rather than dichoptic, (ii) synonym word pairs are tested in this experiment whereas in Marcel's experiment association type was unspecified, but probably not just synonymy, (iii) luminance levels are lower in the present experiment, (iv) nonword priming is not examined in this experiment, and (v) there is no energy masking condition.

2.4.2. Method

(i) Subjects

Twenty-eight first year psychology students (14 male, 14 female) cooperated as part of course requirement. Age range was 17-23 (mean = 20). Subject testing and acceptance criteria were the same as in Experiment 1 (Section 2.2.2). Subjects were randomly assigned to Mask condition first or Nomask condition first.

(ii) Apparatus

The same apparatus and same field luminance setting were used as in Experiment 2 where both are fully described.

(iii) Stimuli

Stimuli were presented in the same case and size as in Experiment 2. As there were not enough synonym pairs in the CFA Norms to provide a sufficient set the extra pairs were derived from Cassell's Dictionary of Synonyms. A total of 20 four-letter word pairs were initially derived in this way. The pairs were then rated for synonymity by ten independent judges and the ten highest rated pairs chosen for the experimental trials. The five next highest were used in the practice trials. The list of words and nonwords for experimental trials is given in Appendix A.1. Word frequencies ranged from 4 to 872 with a mean frequency of 81 per million (Kucera and Francis, 1967).

(iv) Procedure

In the Mask condition procedure was the same as in Experiment 2 (see section 2.3.2 (iv)). For the Nomask condition the procedure was the same as the Nomask condition in Experiment 1, but in this case presentation of all stimuli was binocular.

2.4.3. Results

Table 3

Mean RT's (Msec) to Associated and Unrelated primed targets in Experiment 3

	"Yes" Responses		"No" Responses
	Synonyms	Unrelated	
Masked	698	707	876
Not Masked	653	654	724

Critical SOA's ranged between 10 msec and 60 msec with a mean of 17.3 msec. For 25 subjects there was no difference between pre- and post-experimental critical SOA's. Three subjects gave a post-experimental Critical SOA which was lower than their pre-experimental Critical SOA (2 msec, 2 msec, and 5 msec, respectively). None of these three subjects reported being aware of a prime, or any part of it, during the course of the experiment. Error rate was 2.0% for "Yes" responses and 2.9% for "No" responses.

(i) A two way within subjects ANOVA, with factors Masking (Mask, Nomask) and Response (Yes, No), demonstrates that both the effects of Masking (F

(1,55) = 59.02, $p < .0001$), and Response (F (1,55) = 92.82, $p < .0001$), are significant. Further analysis is of "Yes" responses only.

(ii) A two way within subjects ANOVA on the "Yes" responses alone, with factors Masking (Mask, Nomask) and Prime Type (synonym, unrelated), demonstrates that only the main effect of Masking is significant (F (1,27) = 8.61, $p < .001$). Separate ANOVA's on the critical comparison between synonym and unrelated pairs showed that the neither the 9 msec difference in the Mask condition, nor the 1 msec in the Nomask condition were significant, nor were probabilities even suggestive.

2.4.4. Discussion

(a) Criteria for awareness

The Critical SOA measures pre- and post- LDT trials differed for three subjects but none of these three subjects reported awareness of primes.

(b) Priming effects

The most important result is that there is no priming effect in either the Nomask or the Mask condition. Several investigators have found facilitation for other-associative pairs (Meyer and Schvaneveldt, 1971; Marcel, 1980, 1983a; Fowler et al., 1981) in comparable experiments. It is surprising therefore that in the Nomask condition there is no significant difference between the word groups. Given this failure the lack of priming effects in the Mask condition is predictable. These results suggest that the logical difference between synonyms and other associates may be reflected in RT differences in a lexical decision task. Whether the failure to find associative priming in this experiment is due to the use of a particular set of associated pairs, or because they were synonyms rather than other kinds of associated pairs, will be examined in Experiment 5.

2.5. Experiment 4: Associative Priming in a Binocular LDT.

2.5.1. Introduction

Shortly after Experiment 3 was completed, pre-publication details of some experiments by Slade (Note 5) became available. These experiments were later published, with additional material, by Fowler, Wolford, Slade, and Tassinary (1981). Fowler et al's paper reported replication of some of Marcel's (then unpublished) series of experiments, while failing to replicate the findings of others. They support Marcel's claim that dichoptic presentation of a backward masked associated prime in a LDT produced nonconscious priming effects. Their procedure was similar to Marcel's, but apparatus and display conditions were dissimilar. The significant associative priming effect they obtained in the Mask condition was only 29 msec compared to the 56 msec reported by Marcel. In their pre- publication report the associated word pairs and display conditions were specified in detail, although there was some disparity between reported and actual generation of stimuli. Fowler et al. claim to have generated the stimulus set using the same technique as Marcel (i.e. as in Meyer and Schvaneveldt, 1971). Closer examination revealed that only about 50% of the stimuli could have been derived from the CFA norms, and the remainder constructed on an ad-hoc basis. Fowler et al. do not describe the process of generating these remaining associated word pairs. Nonetheless the important factor was that an associated word set was available which was known to produce both conscious and nonconscious priming under the given conditions.

Both Fowler et al. and Marcel presented stimuli dichoptically. The difficulty in obtaining effective dichoptic masking for large stimuli and the failure to obtain nonconscious repetition priming dichoptically has already been discussed. The present experiment uses a combination of the binocular presentation condition of Experiment 2, which produced nonconscious repetition priming, and the stimulus set used by Fowler et al. This combination of conditions was expected to produce nonconscious associative priming. The apparatus and binocular presentation conditions were similar to several of Marcel's experiments which had also provided evidence of nonconscious associative priming (Marcel, 1980; Marcel, 1983a, Experiments 1, 2, 5, and 6).

The pilot experiments, already described, demonstrated clearly that 40 detection trials were insufficient to determine a stable detection threshold. Fowler et al. however, use only 40 pre-experimental detection trials to determine the critical SOA, but they note that:

> It is true that had we used larger numbers of presence-absence judgements, we might have found that subjects responded with greater than chance accuracy (p.360).

Perceptual adjustment could occur subsequent to the critical SOA procedure and subjects would be aware of the prime word on some occasions during the course of the LDT trials. The validity of the results would then rest entirely on subject report. Should subjects become aware of the true purpose of the experiment by seeing a prime word, then report is susceptible to the demand characteristics of the experiment (Orne, 1962a). "Good" subjects (Orne, 1962a) would be reluctant to disappoint the experimenter by telling him or her that the prime was visible, or in other words, to tell the experimenter that, after an hour's hard work, the experiment had failed. Neither Fowler et al. nor Marcel indicate the form of the post-experimental probe questions they used, nor how detailed they were. The style and methods of probe questioning and debriefing are known to be important in eliciting maximum report from subjects (Morris, 1981b,c; Ericsson and Simon, 1980; Nisbett and Wilson, 1977). To test the suggestion that some subjects are able to detect some primes when only 40 detection trials are used, two separate post experimental probe sessions were designed into the following experiment. The first set of probe questions directly followed the post-experimental SOA trials. The subjects were asked if they had any comments or criticisms of the experiment. The second set of probe questions was designed to overcome subject response bias. The intention was to offer them the chance of being "good" subjects in a situation where "being good" included disclosing that they had seen a prime word if they had done so.

2.5.2. Method

(i) Subjects

Ten female and ten male first year psychology students took part to fulfil a course requirement. Age range was 17-25 with a mean of 20. Subject testing and acceptance criteria were the same as for Experiment 1 (Section 2.2.2).

(ii) Apparatus

The same apparatus was used as detailed for Experiment 3, with the same exposure conditions.

(iii) Stimuli

Letterstrings were taken from the Slade (Note 5) report of experiments later published by Fowler et al. (1981), and are given in Appendix A.3. Word frequency ranged between 1 and 1207 per million with a mean of 95 (Kucera and Francis, 1967). Sixteen of the 64 words had frequencies less than 10. A few American to English spelling changes were necessary (e.g., vigor-vigour). Word pairs were organised into two lists (A and B) such that associated pairs in list A were unrelated in list B and vise-versa. Subjects did not see the same word twice in any one condition. Those receiving list A in the Mask condition had list B in the Nomask condition, preventing the possibility of confounding RT differences with memorial factors (both Fowler et al., and Marcel presented the same word list to the same subjects under both conditions).

Letterstrings were drawn using the method described for Experiment 2. String length varied between three and eight letters, measuring 0.4 in. wide and 1.2 in. wide respectively. Strings subtended a horizontal angle of between 1.2 degrees and 3.4 degrees, and a vertical angle of 0.6 degrees when viewed in the tachistoscope. The mask described for Experiment 3 was used in the present experiment.

(iv) Procedure

Procedure was the same as in Experiment 3, except that the critical SOA was derived on the basis of 40 rather than 100 detection trials. This entailed a modified descending staircase method using coarser steps than in Experiment 3. Twenty four Practice LDT trials were followed by 64 experimental trials. Following the experimental trials 40 post experimental detection trials were given to re-assess the subjects critical SOA. At the end of the post-experimental detection trials (Mask condition only), subjects were given the two sets of probe questions. In the first set, subjects were asked if they had any comments or criticisms to make. If subjects had completed both Mask and Nomask conditions they were debriefed on the aims and method of the experiment, and the experimenter signed the subject's attendance card. This procedure normally signifies the end of the subject's experimental requirement. As the subject was about to leave the room the experimenter introduced the second set probe questions. These questions were primarily addressed to what was being displayed, as contrasted with what the subjects had seen. The experimenter requested some extra help with the experiment, saying that he "was concerned that it was not running properly" and asked for the subject's cooperation. The subject was asked to describe the experimental display sequence in as much detail as possible. This open-ended question was followed by a gradually more specific set. Subjects were asked if they saw: (a) anything (b) any letters and (c) any words, before the mask at any time during the experiment. If subjects reported seeing a word they were asked (a) what the word(s) were, (b) how many there were, (c) where in the experiment they were, and (d) the position in the display they appeared in. If subjects had not reported words or letters before but did so at this point they were asked why this was.

2.5.3. Results

Table 4

Effect of Prime Type, Masking, and Report on "Yes" and "No" Response Latencies in Experiment 4. (Mean RT'S in msec)

		"Yes" Responses		"No" Responses
	n	Associated	Unrelated	Word
Overall Results				
No Mask	20	624	650	725
Mask	20	615	640	750
After first post-Experimental report				
Mask: Report	5	658	707	796
Mask: No Report	15	601	618	739
After second post-Experimental report				
Mask: Report	14	617	657	764
Mask: No Report	6	612	602	707

n = number of subjects in each category.

Critical SOA's ranged from 10 to 48 msec (mean = 26 msec). Post-experimental critical SOA's were lower for 13 subjects with a mean difference of 12.3 msec between the pre- and post- experimental assessment, ranging from 35 msec in one case to only 4 msec in others. The modal difference was 5 msec.

(i) Overall analysis

(a) A two way within subjects ANOVA, with factors Masking (Mask, Nomask) and Response (Yes, No), demonstrates that only the effect of Response is significant (F (1,39) = 99.42, p < .0001). Further analysis is of "Yes" responses only.

(b) A two way within subjects ANOVA, with factors Masking (Mask, Nomask) and Prime Type (associated, unrelated), demonstrates that only the main effect of Prime Type is significant ($\underline{F}$ (1,19) = 10.14, $\underline{p}$ < .01). Separate analyses of the critical comparison between associated and unrelated target RT's revealed that in the Nomask condition the 26 msec facilitation was significant ($\underline{t}$ (19) = 1.8, $\underline{p}$ < .05 (one tailed)). The 25 msec difference in the Mask condition was significant at the same level ($\underline{t}$ (19) = 1.9, p < .05 (one tailed).

<u>(ii) After first probe Questions</u>

When subjects were asked the first question: "Have you any comments or criticisms of the experiment?", it emerged that five subjects reported seeing something other than the target word. Reports ranged from seeing "possibly some letters" to seeing several words, but no subjects reported seeing words from the beginning of the experiment. Response times in the Mask condition were assigned to a "Report" category if subjects reported seeing a word prior to the target word at any time during the experiment (subsequent to the SOA procedure). Subjects who said that they saw only targets were included in the "No Report" category. The critical comparison between associated and unrelated primed target RT's was re-analysed on this basis.

<u>(a) Report Results</u>: The 49 msec difference attributable to priming was not significant ($\underline{t}$ (4) = 1.16). The failure to achieve significance for such a large priming effect is probably due to the small number of subjects (5) and the high variance in the RT scores.

<u>(b) No Report Results</u>: The 17 msec difference attributable to priming was also not significant ($\underline{t}$ (14) = 1.58), though it approaches significance at the 5% level (critical $\underline{t}$ (14) = 1.76);

<u>(iii) After Second probe questions</u>

When subjects were asked to help the experimenter in the second set of questions - which were addressed to what was being displayed rather than what the subjects had seen - a further nine subjects reported having seen something they took to be a word or letters on some occasions, prior to the target word. Report categories were assigned on the same basis as in the analysis following the first series of questions.

(a) Report Results: For the fourteen Report subjects the 40 msec. difference attributable to priming was significant (t (13) = 2.33, $p < .05$).

(b) No Report Results: For the six No Report subjects the 10 msec difference, in the opposite direction to that predicted, was not significant.

2.5.4. Discussion

(a) Criteria for Awareness

The critical SOA procedure was insufficient in the present experiment to ensure effective masking throughout the experimental LDT trials. Seventy per cent of subjects later reported having seen at least letters of the prime, and several subjects reported seeing words. Moreover a subject report bias was clearly demonstrated by the nine subjects who initially did not report that they had seen something. Comparison with subject report in Experiments 1, 2 and 3 indicates that the number of trials to criterion influences the effectiveness of the critical SOA technique. The implication is that the SOA technique may also have been ineffective in producing lack of awareness in both Marcel's and Fowler et al.'s experiments. However, there are differences in mode of presentation. How important this is to the fact that subjects became aware of the prime word is difficult to decide. There are noticeable similarities between the two experiments and certain conjectures may be permissable. The range of critical SOA's in Fowler et al. (1981) was 10 - 70 msec with all but one between 10 and 30 msec. In the present experiment, although the range was less (10 - 48 msec), there were five subjects whose critical SOA was in excess of 30 msec. In the present experiment the critical SOA for thirteen subjects was lower on the post experimental test than on the prior one whereas in Fowler et al.'s there were only nine. Furthermore, perceptual adjustment may have occurred for other subjects whose initial SOA was the minimum 10 msec. The number of SOA's at 10 msec was not reported in Fowler et al.'s paper, but in the present experiment with comparable (and slightly higher) SOA's there were seven subjects with a critical SOA of 10 msec. As 10 msec was the minimum SOA used, subjects with pre-experimental SOA's of 10 msec will have post experimental SOA's of 10 msec, regardless of any change in their detection sensitivity. The reduction between pre- and post- experimental detection thresholds for both Experiment 4 and Fowler et al's comparable experiment (Experiment 5) lends credence to the suggestion that some form of perceptual adaptation may take place. This may be due to (a) a change in task sensitivity between the detection and lexical decision tasks, or (b) to repeated presentations of a prime word during the experimental trials leading to adaptation, or both.

(b) Priming effects

In the Nomask condition the significant 26 msec associative priming effect is comparable to the 32 msec obtained by Fowler et al. for the same set of word pairs, but considerably less than the 62 msec effect obtained by Marcel with unknown associated pairs. The reduced conscious priming in the present experiment may be attributed to the differences in word usage and word association between American and British English speakers. For example, "roosters", while recognisable in British english, is not a common associate of "chickens", nor are "power" and "vigour" or "crew" and "gang" common associates according to the Kiss, Armstrong, Milroy, and Piper (1973) Association Norms for British English.

When RT's are reanalysed according to the answers to the second set of questions, then for the fourteen subjects who reported seeing letters or a word, there is significant priming of 40 msec. For the six subjects who did not report being aware of a prime word, the "priming effect" is (nonsignificantly) in the opposite direction. The difference between the overall analysis and the results after the two sets of questions is striking. Merely asking for comments and criticisms does not appear to be enough to gain the necessary information from subjects. The subject's active cooperation has to be obtained and there must be some way of overcoming the biases operating in the situation.

There are further factors involving subject report which may increase the effect on response to the second questioning discussed above. Post-experimental analysis relies on what the subjects can remember after completing 40 critical SOA trials; 24 practice LDT trials; 64 experimental trials; 40 post experimental SOA trials; thinking about comments and criticisms; and possibly reorienting towards their next destination. It may be that other subjects were aware of the prime word at the time it was presented but subsequently forgot the event.

2.6. Discussion: Priming without Awareness and Marcel's Critical SOA Technique.

2.6.1. Results of preceding experiments

The initial objective of the preceding experiments was to provide a baseline working method to enable further investigations of nonconscious processing. Marcel's Critical SOA procedure assumes (i) that there is a detection "threshold", (ii) that this threshold is relatively stable, (iii) that adequate criteria are used to determine this threshold. The results of the preceding experiments demonstrate that:

1. It was not possible to replicate Marcel's reported exposure conditions on the same make and model tachistoscope.

2. Results of the pilot experiments and those of Experiment 4 indicate that 40 presence-absence detection trials are insufficient to adequately determine a sensitive non-detection threshold. This is indicated by (a) the high proportion of subjects whose post-experimental critical SOA was lower than their pre-experimental critical SOA (Pilot experiments; Experiment 4;

Fowler et al., 1981, Experiment 5), (b) the ability by some subjects to detect prime words and letters in the LDT when they were performing at 60% correct or less in the detection task (Experiment 4).

3. A critical SOA assessed using 100 detection trials produced a more sensitive measure. However, most subjects were able to identify dichoptically presented primes at the minimum SOA.

4. When 100 detection trials were used, and presentation was dichoptic, the size of the prime words was reduced in order to mask them sufficiently to obtain performance at or below the 60% correct criterion. This technique did not provide evidence for nonconscious repetition priming in a subsequent LDT (Experiment 1).

5. When 100 detection trials were used, binocular presentation of stimuli comparable in size to Marcel's produced evidence for nonconscious repetition priming (Experiment 2).

6. When 100 detection trials were used, with presentation and exposure conditions similar to Experiment 2, there was no evidence for nonconscious associative priming (Experiment 3).

7. When only 40 detection trials were used, with presentation and exposure conditions similar to Experiment 2, there was marginally significant evidence for "nonconscious" associative priming (Experiment 4). However the "measure" of the detection threshold was insufficiently sensitive to prevent identification of prime(s) by some subjects. Further questioning of subjects indicates that (i) some subjects may have been aware of the prime words or letters, (ii) there is no evidence of associative priming for those subjects who did not report seeing a word (Experiment 4).

8. The experimenter had to rely on subject report in order to separate out the contribution made by subjects who could have detected the masked word on some occasions.

9. "Demand characteristics" may generate a reluctance by some subjects to report awareness of the prime word(s) (Experiment 4).

The results seriously undermine Marcel's claim that in his Experiment 4: (a) his critical SOA technique is effective in providing a situation where subjects could not have detected the prime word in the LDT as they could not detect the presence of words in the prior presence-absence detection task, (b) associative priming effects can be demonstrated when subjects are unable to detect the presence of the prime. These two issues will be dealt with separately.

2.6.2. Re-evaluation of criteria for awareness

Psychophysical thresholds are known to be subject to adaptation and therefore require lengthy procedures over a period of time for reliable establishment. A "threshold" derived from 40 trials over a short period of time is neither sensitive nor stable and may decrease with continued exposure to the same presentation and exposure conditions. Lengthy formal and informal testing suggests that phenomenal awareness of a meaningful stimulus such as letters or a word is not gradual and piecemeal but sudden and complete. Kinsbourne and Warrington (1962b) also found that several letters became identifiable simultaneously as SOA was increased. The results of the above experiments demonstrate clearly the inadequacy of Marcel's critical SOA technique. Further support, subsequent to the experiments reported here, comes from Merikle (1982) and Diaper (Notes 1 and 2).

Merikle (1982) presents a vigorous attack on the SOA procedure in both Marcel's and Fowler et al.'s (1981) experiments. He points out that the validity of the claims for nonconscious processing "depends entirely upon the adequacy of the procedures used to determine the thresholds" (p.298). Merikle suggests that subjects may fail to change their original response criterion for Yes-No responses concommitant with the decrease in stimulus availablity. His claim that this leads to a "very stringent criterion for deciding 'Yes'", and therefore a conservative detection threshold, cannot be easily dismissed. It is true that Marcel, Fowler et al., and myself encouraged subjects to respond "Yes" to a blur or dark patch in the centre of the field, but this encouragement is not necessarily sufficient to ensure a change in subjects' response criteria. The point made earlier and endorsed by Merikle, and the one which is absolutely central to the whole SOA problem, is that there were far too few trials upon which to establish a threshold.

Diaper (Notes 1 and 2) provides substantial empirical support for the criticisms of the SOA reported above. He demonstrates that a low ratio of detection to nondetection trials provides an insensitive measure for lack of awareness, although evidence for nonconscious processing may be obtained under such conditions. He concludes that it is not possible either empirically or statistically to endorse Marcel's claim that subjects could not have detected the prime in the LDT because they could not accurately detect its presence on a different, prior task. According to Diaper there is no known method for equating sensitivity on the two tasks.

The inadequacy of the critical SOA technique necessitated recourse to subject report in order to determine lack of awareness in Experiment 4. Subject's report strategies should therefore be seriously considered. In Experiment 4 subjects may have been reluctant to report awareness of the prime for the reasons discussed earlier. Subjects wishing to be "good" subjects may not want to spoil the experiment. Subjects wishing to be "bad" may withold information they thought was important. This experimenter became very aware of the demand characteristics in the first series of experiments. All subjects came from the same pool (first year psychology students). The fact that participation in experiments was compulsory was not always accepted with enthusiasm. Demand characteristics should not be trivialised in the context of this type of experiment. After all, the experimenter is practicing a certain amount of "deception" on the subjects. If subjects notice this, it should not be surprising if on some occasions they practice a little of their own.

2.6.3. Priming without awareness

Nonconscious repetition priming was demonstrated under binocular but not dichoptic presentation conditions (Experiments 1 and 2). Failure to produce nonconscious effects in Experiment 1 may be attributed to the small size of prime words. There is no evidence for nonconscious associative priming when a stringent criterion for lack of awareness is adopted. These findings are supported by the results of three (so far) unpublished studies (Creighton, Notes 6 and 7; Evett, Note 8; Diaper, Notes 1 and 2).

Creighton (Notes 1 and 2) reported similar dissatisfaction with the critical SOA procedure. He found that under dichoptic presentation, some subjects had great difficulty in perceiving the masked word in the critical SOA trials, even at an SOA of 100 msec. Subjects had to be "educated" as he put it, in order to detect the prime (presented to the non-dominant eye) because often the mask (presented to the dominant eye) was all that the subject could detect. Subjects were "bullied" (Creighton) into not responding "No" all the time, and to concentrate on the detection task. Once subjects were able to perform this task they tended to be able to do so down to very low SOA's. For example, 25% of Creighton's subjects were still performing better than chance at 10 msec SOA (0 msec ISI), and critical SOA's overall were between 10 and 25 msec. Marcel did not provide the critical SOA values for his Experiment 4, which is a most important omission. Creighton's results were similar to those of the present experiments. He was also unable to find any nonconscious associative priming effects "or even suggestive effects" when he used either Marcel's original technique or an improved up-down adaptive procedure for assessing the critical SOA. Evett (Note 8) also found difficulty in replicating the procedure described by Marcel and did not obtain evidence for nonconscious associative priming using his paradigm. Diaper's (Notes 1 and 2) results are that if the ratio between detection and LDT trials is low then pseudo-nonconscious effects will be found. However if the ratio is high then nonconscious associative priming will not be found.

2.6.4. Summary

The evidence from the present experiments and others (Creighton, Notes 6 and 7; Evett, Note 8; Diaper, Notes 1 and 2) strongly suggests that the critical SOA procedure is inadequate and under some circumstances the prime could have been detected by some subjects on some trials. Responses based on this detection may be responsible for the supposedly nonconscious effects observed (e.g., Marcel, 1983a, Experiment 4; Fowler et al., 1981, Experiment 5). Whenever a more stringent criterion for establishing the critical SOA is adopted by (a) increasing the number of trials, (b) using a more sensitive up-down adaptive procedure (Creighton), or (c) adopting a careful post-experimental probe procedure to determine awareness, then the nonconscious associative priming effect disappears.

CHAPTER THREE

Priming lexical decisions where awareness is determined by subject report

3.1. Introduction

Marcel's (1983a) claim that associative priming can occur nonconsciously was not supported by the preceding experiments. In Experiment 2, nonconscious repetition priming effects were observed when primes were binocularly backward pattern masked. As both prime and target were identical, priming could have occurred at any locus between early feature level description and higher order lexical representation. Experiments 3 and 4 failed to provide evidence for associative priming. Various improvements of method were needed to increase the chances that any such effects that do occur would be revealed. The work described in this Chapter was undertaken to: (a) provide improvements in method and procedure, (b) to establish large association effects when both prime and target were clearly visible, and (c) to investigate nonconscious associative priming under the conditions established in (a) and (b). Experiments 5 and 6 were designed to maximise associative priming effects in a Nomask condition, in order to increase the chance of nonconscious associative priming in a Mask condition (Experiments 7, 8, and 9).

3.2. Improvements in Method.

Nonconscious priming effects are typically small, while variance under some circumstances can be quite high (e.g., in Experiment 4). To reduce variance the decision was made to (a) increase the number of experimental trials per subject, and (b) provide the subject with trial by trial knowledge of results in order to reduce both RT and errors. The apparatus used in the previous experiments did not easily enable these changes. The tachistoscope is sensitive and finely adjustable, but effective operation is slow over a large number of trials. As subjects were only available for 45 minutes the number of trials per session was limited by the speed and accuracy with which the experimenter could manually operate the tachistoscope. In order to fulfil these requirements an Apple II Microcomputer was adapted to operate as a tachistoscope. Software was developed to (a) present stimuli at a rate dependent only on subject limitations, in order to allow a substantial increase in the number of trials per subject, (b) to provide comprehensive knowledge of results to subjects, and (c) to automate the procedure to reduce both experimenter error and the possible extent of demand characteristics.

The procedure for assessing awareness was also changed. In the following series of experiments, awareness is determined on the basis of retrospective subject report. This will be more fully discussed in Section 3.6.1(b).

3.3. Selection of associated word pairs

The second improvement was to compile a word set which could provide large and robust priming effects. The failure to achieve synonym priming in the Nomask condition in Experiment 3 is puzzling, considering the substantial evidence for associative priming under similar conditions (Meyer and Schvaneveldt, 1971; Marcel, 1980, 1983; Fischler, 1977; Fischler and Goodman, 1978). It is possible that degree of associative priming may depend on type of associative relationship.

The CFA Norms (Bousfield et al., 1961) provided the source from which both Marcel and Fowler et al. claim to have derived their associated pairs (using a method described by Meyer et al., 1971). The CFA Norms contain a variety of parts of speech (e.g., nouns, verbs, adverbs) and variety of associative relations (e.g., synonym, antonym, categorical). Association strength also varies across pairs (association strength is calculated by the number of subjects giving a particular first associate to a particular word expressed as a proportion of the total number of associates to that word).

As a first step in selecting a set of associated word pairs which produce a large conscious priming effect, the following experiment was designed. It investigates differences in the degree of priming between synonyms and other forms of associative relationships (the latter will be simply called associates).

3.4. Experiment 5: The effect of associative relationship on priming

3.4.1. Introduction

In the Nomask condition of Experiment 3, synonym priming was only 5 msec compared with 26 msec associative priming in Experiment 4. The word pairs in Experiment 4 however, consisted of 20 synonyms and 12 associated words. A by-word analysis of the data was undertaken to see if there were differences in the mean RT's. Three associative pairs were excluded from the analysis on the basis that they were neither synonyms nor appeared in either the CFA Norms or the Kiss et al. (1973) Association Norms for British English (these were power- vigour, crew-gang, and chickens-roosters). The by word analysis showed that the mean RT for the 20 synonyms pairs was 630 msec compared to 543 msec for the 9 associated pairs. The 87 msec difference was significant ($\underline{t}$ (28) = 4.77, $\underline{p}$ < .001). This suggests that synonyms prime less than associates. Experiment 5 was designed to test this possibility more directly.

3.4.2. Method

(i) Subjects

Eleven female and eleven male first year psychology students participated as part of course requirements. Age range was 18 to 31, with a mean age of 21.7. Subject testing and acceptance criteria were the same as for Experiment 1.

(ii) Apparatus

As the situation and apparatus used in the following experiment was the same for all further experiments it will be fully described at this point. Subsequent modifications will be detailed by experiment.

(a) Situation

A new laboratory was used consisting of a testing room with communication via a microphone and loudspeaker link to a control room which housed a microcomputer. Dixon (1971) and Marcel (1983) have suggested that a relaxed and passive attitude by subjects increases the effect of nonconscious processing. In addition, several authors (e.g., Kolers, 1983; Matula, 1981) have reviewed evidence which indicates that prolonged viewing of a CRT screen can produce visual fatigue and muscle strain. The task environment itself seems to be an important factor in producing fatigue, in addition to glare from high contrast visual displays on the CRT. Consequently every effort was made to provide a relaxing and comfortable experimental environment. Soft chairs were provided and the testing room was backlit under low illumination (background room luminance was 2.5 foot lamberts). VDU brightness and contrast were reduced to a level which allowed comfortable viewing with accurate performance.

(b) Equipment

The microcomputer was an Apple II with 48K of RAM Memory. A two disc system allowed for independent program storage and data collection. Output was to a purpose built 15" VDU screen utilising a P46 (yellow-green) phosphor. This phosphor gave an effectively instantaneous rise and fall time for displayed material (decay time to 10% = 160 ns), allowing accurate display timing. Stimulus luminance, determined from a 6 * 6 array of asterisks, measured 3 ft lamberts (6 microwatts), and remained at this level throughout all of the following experiments. Timing was effected via additional hardware along with minor modifications to the microcomputer. A John Bell Engineering dual 6522 VIA Board generated interrupts for timing. The software necessary to run this (Hales, Note 13) was modified to provide accurate millisecond timing from display onset to response. Timing accuracy was increased by modifying the AN3 output games port and the frame synchronisation pulse line, enabling all operations to commence at frame blank onset. The response board was similar to that used in Experiments 1 - 4 and consisted of three buttons 3.3 in. apart arranged in an inverted triangle. The top two response buttons were labelled "YES" and "NO" and were changed according to subject's handedness. "YES" responses were always to the subjects dominant hand. The "START" button initiated each display by interrupting a "wait" command in the program.

(iii) Prime and Target words

Words were all concrete nouns of between three and seven letters. Word frequency for synonyms ranged from 1 to 1772 per million with a mean of 78. Word frequency for associated words ranged from 1 to 1207 with a mean frequency of 81 per million (Kucera and Francis, 1967). Synonym word pairs were taken from the CFA norms, selecting for those pairs with the highest associative strength. Supplementary items were taken from Wilding and Mohindra (1981) selecting for pairs rated highest in synonymity. The Wilding and Mohindra ratings (assessed on a 1 to 7 scale) ranged between 4.13 and 6.14 with a mean of 5.49. Associated word pairs were taken from the CFA Norms selecting for those pairs which had the highest associative strength. All were first associates where the range of associative strength was between 13% and 82%, with a mean of 42%. Unrelated word pairs were produced by recombination of synonyms or associates to produce pairs which were not related in any obvious way. Nonword targets were generated by changing one letter, usually a consonant, in concrete nouns of similar frequency to the target word set. Synonyms and associates were balanced as far as possible for (a) string length, (b) word frequency, and (c) concreteness (Paivio, 1968)). The latter was difficult to achieve because of the restricted set of stimuli for which concreteness ratings were available. However, all words were concrete nouns. Where ratings were available (assessed on a 1 to 7 scale) they ranged between 5.83 and 7 with a mean of 6.71. Nonword targets were all high approximations to English and balanced for string length only. Two lists (A and B), were constructed such that individual prime and target words appeared only once in each block of trials. Each list consisted of 12 pairs of each type of relationship. The practice list was constructed in similar fashion with only 10 words in each group. All list items were presented in random order. Words and nonwords used in experimental trials are given in Appendix A.4.

Letterstrings measured between 0.7 in. and 1.3 in. wide by 0.2 in. high, subtending a horizontal visual angle of between 1.3 and 2.85 degrees, and vertical angle of 0.45 degrees when viewed at 26 inches. All stimuli appeared as light green on a dark green background.

(iv) Procedure

Subjects were tested for acuity and seated in front of the VDU. The screen position was adjusted to provide a viewing distance of approximately 26 inches. The experimenter started the program from the control room, and thereafter subjects controlled the experiment at their own pace, via the program. Four pages of instructions were displayed on the screen, the full text of which is given in Appendix A.5. Briefly, the subject was familiarised with nonwords (definition, description and examples), and told that two arrows would appear in the centre of the screen. Shortly after pressing "START" a word would appear between the arrows, then disappear, followed by a string of letters which would be either a word or a nonword. The subject's task was to respond as fast as possible to the second letterstring by pressing the appropriate button ("YES" for word, "NO" for nonword).

(v) Presentation sequence (see Figure 5)

During the resting stage 2 arrows were displayed (-> <-) 1.4 in. apart in the centre of the screen. The arrows remained on throughout the trial. The subject initiated each trial by pressing "START". A 500 msec waiting period was followed by a 500 msec display of the prime word immediately between the arrows. A 1500 msec display of arrows only was followed by the target word which remained on until subject response. This was the end of the trial, which was followed by appropriate feedback messages. Prime-target SOA was 2000 msec. Forty practice trials (10 of each condition randomly presented), were followed by two blocks of 48 experimental trials. Half of the subjects received List A first followed by List B, and half in the reverse order.

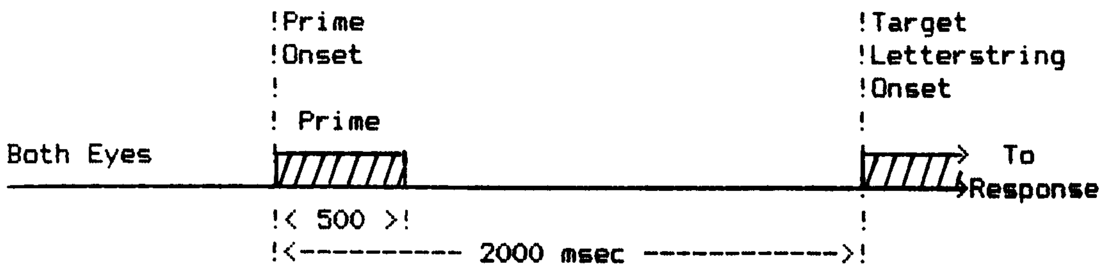


Figure 5

Presentation sequence for Experiment 5

(vi) Knowledge of results

Two systems provided knowledge of results. These were intended to speed responses while keeping errors to a minimum. A second aim was to counteract the "Yes" response bias produced by the 3 : 1 word to nonword target ratio.

(a) Practice trials only

The RT for the previous response appeared above the displayed target at the end of each trial. If the RT was less than 800 msec the word "GOOD" appeared underneath the target, for RT's between 800 and 1500 msec the word "SLOW" appeared, but if RT exceeded 1500 msec the message was "TOO LATE".

Word pairs with target RT's in excess of 1500 msec were re-presented at the end of the sequence. If a response error was made then the message "ERROR : YOU PRESSED THE WRONG BUTTON" appeared below the rest of the display.

(b) All trials

If three errors were made in any one block the display disappeared and the following message appeared in the centre of the screen: "NOTE: YOU HAVE MADE (3) ERRORS SO FAR IN THIS BLOCK, PLEASE CONCENTRATE ON THE TASK". The message was updated and reappeared following every three errors and alternately the latter part of the message read: "PLEASE TRY HARDER". At the end of each block the subject was provided with mean RT's for words and nonwords, and both type and number of errors. Error scores and R.T's were reset to zero at the end of each block.

3.4.3. Results

Table 5

Effect of Associative Relationship on Mean RT's (msec) in Experiment 5

"Yes" Responses			"No" Responses
Associated	Synonym	Unrelated	Word/Nonword
482	514	518	622

(a) "Yes" and "No" responses

Errors to word targets were 1.45%. There were fewer errors to associated words than to either synonyms or unrelated words. Errors to nonwords were 6.8%. The mean RT for correct "Yes" responses (Words) was 505 msec compared with 625 msec for correct "No" (Nonword) responses. The difference of 120 msec is significant (t (42) = 5.27, p < .001). As this experiment is not primarily concerned with word / nonword differences further analysis is of "Yes" responses only.

(b) Priming effects

An overall one way within subjects ANOVA on "Yes" responses only to determine the effect of Prime type (synonym, associated, unrelated), is significant (F (2,42) = 28.55, p < .0001). Separate analyses performed to compare each of the Prime types showed that (i) the 36 msec RT difference between associated and unrelated RT's is significant (t (21) = 6.28, p< .001), (ii) the 32 msec difference between associated and synonym RT's is significant (t (21) = 6.35, p < .001), but (iii) the 4 msec difference between synonym and unrelated RT's is not significant.

3.4.4. Discussion

The results show that RT's for synonyms were significantly slower than RT's for associated words, and the comparison with unrelated words indicates that synonyms provide significantly less priming. Priming for associated pairs (36 msec) compares favourably with the 38 msec associative priming reported by Fowler et al. (1981). This experiment was specifically aimed at trying to understand the reasons for the failure to achieve conscious priming in Experiment 3, and in retrospect it was a poor decision to use synonym word pairs in that experiment. As only twelve pairs of synonyms and associates were tested no strong conclusions can be drawn, but why synonyms prime less than associates is not clear. Schvaneveldt and Meyer (1973) suggested that the effect of association in a LDT was due to a "spread of activation" from location to location in semantic memory. Spreading activation following prime encoding leads to raised activation in related nodes, facilitating subsequent access (Meyer, Schvaneveldt and Ruddy, 1975). According to Collins and Loftus (1975), the degree of activation in related nodes following presentation of an associative prime depends on several factors; (a) strength of prime-target association, (b) elapsed time from prime to target presentation, and (c) the distance between the two units in semantic space. This experiment mainly addresses the latter aspect (c). There is a high degree of overlap between feature lists for synonyms. These shared features should result in closer proximity in semantic space than would an associated word which shared fewer features. Therefore synonyms should prime more than associates. However, a major difference between synonyms and associates is that sentence production often requires a choice between synonyms, but a selection of both associates. Associates such as Bread and Butter will often occur close together in the speech stream. Although synonyms share features, and may be more proximal in some semantic system, the amount of facilitation may also depend on the probability of one word following another. Whatever the explanation for these differences, the results aid the selection of associated word pairs providing large conscious priming.

3.5. Experiment 6: The effect of prime - target SOA on conscious associative priming.

3.5.1. Introduction

The present experiment continues with the attempt to maximise conscious associative priming. Collins and Loftus (1975) suggest that (a) association strength, and (b) prime - target SOA are important determinants of degree of priming. The latter issue is further investigated in this experiment.

(a) The effect of association strength on priming.

There has been considerable disagreement on whether association strength does affect priming. Fischler (1977b) did not find a correlation between association strength and amount of facilitation, and neither did Neely (1977) find a difference in priming between high and low category exemplars. In Warren's (1977) experiment using a naming task there was no difference in facilitation between moderately associated (34%) and strongly associated (64%) words. On the other hand, Fischler and Goodman (1978) did find a significant difference between strong and weak associates in a post-hoc analysis of their data. Similarly in de Groot et al.'s (1982) experiment strong associates with an associative strength of 40% and above provided substantial priming whereas weak associates of less than 3% did not. De Groot et al. attributed the lack of agreement on the effect of association strength in LDT experiments to differences in the "neutral" prime baseline. Both Neely and Fischler used a row of crosses as neutral priming condition. According to de Groot et al.'s experiments, a row of crosses inhibits processing of a following target relative to repeated presentation of the word "Blank". The choice of neutral prime is important in determining priming effects. For example, in de Groot et al.'s experiment the 19 msec facilitation for strong associates is increased to 35 msec if measured from the "crosses" neutral baseline, and priming is 41 msec when associates are compared with unrelated words. In Marcel's (1983a) experiments the related / unrelated comparison was used to measure priming effects and the same comparison will be used in the following experiments. Furthermore, strength of association will be maximised in selection of associated word pairs for the lexical decision task.

(b) The Prime - Target SOA

The second issue was the effect of SOA on priming. It was necessary to establish an SOA which would provide maximum target priming in the LDT. If SOA is too short activation may not have had time to build up, while if too long the activation may have decayed. The time course of nonconscious priming has not been established, but the evidence is that automatic processes arise earlier than conscious attentional ones (Neely, 1977; Fischler and Goodman, 1978). In both Marcel (1983) and Fowler et al.'s (1981) experiments the SOA was 2000 msec. In de Groot et al.'s (1982) experiment an SOA of 460 msec produced more priming than the same stimulus set presented at 920 msec SOA. Neely (1976) found greater priming at 600 msec than at 360 msec SOA, although in this study SOA and prime duration were confounded. In his 1977 study, where SOA and prime duration were not confounded, maximum associative priming was obtained at 400 msec SOA. Fischler and Goodman (1978) however, found that associative priming was greater at 550 msec SOA than at 90 msec SOA but was still present at 40 msec SOA. Conversely, Fowler et al. (1981, Experiment 6) failed to achieve any associative priming effect when the SOA was reduced from 2000 to 200 msec. Although there is a lack of agreement between experiments, the bulk of the evidence suggests that maximum priming should occur somewhere between 460 msec (de Groot et al., 1982) and 1000 msec SOA (Becker, 1980). Within this range several investigators have found large associative priming effects at 600 msec SOA in a lexical decision task (Neely, 1976; Lorsch, 1982).

In the following experiment a stimulus set intended to produce large associative priming was tested at both a short (600 msec) and a long (2000 msec) prime - target SOA.

3.5.3. Method

(i) Subjects

Ten male and twenty female first year psychology students participated as part of a course requirement. Ages ranged from 17 to 34 with a mean age of 20.3. All subjects were tested to have 6/6 vision.

(ii) Apparatus was the same as in Experiment 5.

(iii) Prime and Target pairs

For the experimental trials 112 word pairs were selected, of which 28 were word-nonword pairs. All words were concrete nouns of between three and six letters. Word frequency varied between 3 and 1772 per million (Kucera and Francis, 1967), with a mean frequency of 86.33. Mean frequency was approximately the same for both primes (86.9) and targets (85.7). Associated word pairs were selected to maximise association strength. Thirty eight were taken from the CFA norms. They were all first associates with association strengths of between 32% and 82%, with a mean of 43.7%. The other 46 pairs were derived from Kiss et al. (1973), either directly or via the MRC Psycholinguistic Database (Coltheart, 1981). These were also first associates, with association strengths of between 30 and 91, with a mean of 50.64. Fourth order approximation to English nonwords were constructed and balanced with the word list for string length and initial consonant. Associated word primes are shown in Appendix A.6, and word-nonword pairs in Appendix A.7. Separate lists (A, B, and C) were designed such that each list contained a particular prime or target only once. A repetition target in list A was thus an associated target in list B and an unrelated target in list C. Across lists each word was presented under the three priming conditions (repetition, associated, unrelated). The target order was randomised once, and then presented in the same order for each for each list; only the prime-target relationship was altered. Word - nonword pairs were the same for each list. The 40 practice pairs were constructed on the same basis as the experimental trials. All subjects received the same practice set.

Presentation conditions were the same as in Experiment 5, except that half of the subjects in each group were presented with the sequence at 2000 msec prime-target SOA and half of the subjects at 600 msec SOA.

(iv) Procedure

Subjects were randomly allocated to lists and SOA treatment. The procedure followed was described in detail for Experiment 5. In the 40 practice trials a display provided feedback on RT and errors to the subject. A two minute rest period followed during which the subject was encouraged (via the program) to seek help, advice or information from the experimenter. The 112 Experimental trials were then presented in three blocks (38, 37 and 37 trials respectively). There was a two minute rest period between each block. During experimental blocks the trial by trial knowledge of results feedback was discontinued, but error messages were provided following every third error as in Experiment 5.

3.5.3. Results

(a) "Yes" and "No" responses

Response latencies are displayed in Table 6. Error rate was 1.4% for "Yes" responses and 5% for "No" responses. An overall two way within subjects ANOVA was performed with factors Response (Yes, No) and SOA (2000 and 600). "Yes" responses were significantly faster than "No" responses at both SOA's (F (1,28) = 105.28, p < .0001). Responses were significantly faster at 2000 msec than 600 msec SOA (F (1,28) = 5.05, p < .05). Further analysis is of "Yes" responses only.

Table 6

Mean RT's (msec) by Prime type at 600 msec and 2000 msec SOA in Experiment 6

	"Yes" Responses			"No" Responses
	Repetition	Associated	Unrelated	Word/Nonword
SOA				
600 msec	490	546	590	695
2000 msec	470	499	539	637

Table 7

Priming effects relative to the mean unrelated RT (msec)

	Repetition	Associated
600 msec	100	44
2000 msec	69	40

(b) Priming Effects

An overall two way ANOVA was performed with across subjects factor SOA (600, 2000) and within subjects factor Prime Type (repetition, associated, unrelated). The main effect of SOA is significant (F (1,28) = 4.47, $p < .05$) as is the effect of Prime type (F (2,56) = 60.32, $p < .0001$). Separate analyses were performed to see if the RT's for each condition differed significantly between 600 and 2000 msec SOA. There is no difference in repetition RT's across SOA. However there are significant differences for both the associated (t (28) = 2.38, $p < .05$) and the unrelated RT's (t (28) = 2.37, $p < .05$) across the two SOA's.

Priming effects displayed in Table 7 show that there is greater absolute priming at 600 msec SOA than at 2000 msec SOA. Additional analysis for the 600 msec SOA revealed that (a) the 100 msec RT difference between the repetition and unrelated targets is significant (t (14) = 6.92, $p < .001$), (b) the 44 msec difference between the associated and unrelated RT's is significant (t (14) = 7.35, $p < .001$), and (c) the 56 msec difference between associated and repetition target RT's is also significant (t (14) = 4.44, $p < .01$).

3.5.4. Discussion

The greater repetition priming at 600 msec than at 2000 msec SOA is consistent with the pattern of results obtained in similar experiments (Neely, 1976; de Groot et al., 1981). The present result of 40 msec associative priming is within the range of previous findings (Fowler et al., 1981; de Groot et al., 1981; Marcel, 1983). The 600 msec SOA was sufficiently long for both automatic and conscious attentional processes to be operating (Neely, 1977). As priming was assessed by the difference between associated and unrelated primed targets, it is the product of both inhibition and facilitation effects. A post hoc analysis was performed to see if there were any differences in priming between the two SOA treatments. The priming effect was calculated for each subject at the two SOA's and a t

test was performed on the two sets of scores. The 4 msec difference in associative priming between 600 msec and 2000 msec SOA is not significant. Repetition priming was significantly greater at 600 than at 2000 msec SOA ($t_{(28)} = 1.83$, $p < .05$ (1 tailed)). The decision was made to use the 600 msec SOA to investigate nonconscious priming in the following experiments in view of the claim that automatic priming effects occur earlier than conscious attentional effects (Neely, 1977; Fischler and Goodman, 1978; Posner and Snyder, 1975).

3.6. Experiment 7: Priming without awareness in a binocular LDT where awareness is determined by post-experimental subject report.

3.6.1. Introduction

Having established a set of associated words which provides substantial conscious priming, the next step was to determine the conditions for nonconscious priming. This involved two main issues; (a) the display parameters for effective masking, and (b) the criteria for determining lack of awareness.

(a) Conditions for effective masking

The refresh cycle for the microcomputer and VDU was 20 msec, therefore display times were in multiples of 20 msec. In informal testing effective masking was produced by: (i) a mask consisting of non-alphanumeric typeface characters (e.g., £ $ & % *), used in conjunction with (ii) a 20 msec display of the prime followed by a 100 msec display of the mask. The biggest problem with binocular presentation is peripheral masking, although nonconscious repetition priming has been demonstrated under these conditions (Experiment 2).

(b) Assessing awareness

Dissatisfaction with the critical SOA technique for determining awareness has already been discussed at length. An alternative procedure is to use a systematic method for eliciting accurate report from subjects. There are three interrelated issues (i) the time at which subjects are asked to report during the course of the experiment, (ii) the particular instructions given to subjects, and (iii) the method of questioning subjects.

(i) Time of report

Dixon's (1971) second criterion is adopted to determine lack of awareness for all the following experiments, that is "The retrospective reporting by the subject that he neither saw (nor heard) anything of the prime" (p. 12). However it was pointed out in Chapter One that this criterion could be divided into (a) a trial by trial prime discrimination report either prior to the LDT, or (b) subsequent to the LDT, or (c) a post experimental report of whether subjects were aware of the primes. Other loci for report are possible, as are combinations of the above.

(ii) Instructions

The instructions relevant to report will be partly determined by when the subjects are asked to report. The instructions are also likely to determine how subjects allocate their attention. For example, in the following experiment, report was post- experimental and there was no statement or implication in the initial instructions that a prime word would be presented. Subjects were asked to concentrate on the space between two arrows where a string of symbols (the mask) would appear, and were told that the symbols would act as a warning that the LDT letterstring was about to follow. This instruction was intended to direct their attention to the appropriate area of the visual field but without directing them to concentrate on prime detection (prime detection was low under the given conditions even when subjects were informed of their presence). At the end of the experiment subjects were asked a set of questions to determine their awareness of primes. The nature of these questions is important.

(iii) Post-experimental questions

The use of subject retrospective report is still at the centre of controversy (Morris, 1981; Evans, (1980a); Nisbett and Wilson, 1977). Further discussion of this issue will be dealt with in Chapter Five. Two principles were adopted for post experimental questioning; (a) that the primary question should be indirect, and (b) that the subjects are asked only simple direct questions further to (a). The second set of questions used in Experiment 4 were considered adequate to fulfill these principles, particularly the primary question "Please describe the display sequence in as much detail as you can". These questions were designed to reduce the effect of demand characteristics by (i) non-directive questioning, and (ii) allowing the subjects to describe the sequence in their own language.

Subjects who reported having seen a word or letters other than the target on some trials were to be included in a post- experimental "Report" category, while those subjects reporting that they saw nothing other than mask or target on any trial were to be included in a "No Report" category. Priming effects in the No Report category were regarded as evidence for nonconscious processing under the given conditions. The original decision to restrict the No Report category to reports that nothing at all was seen of the prime, was modified following several reports from subjects during informal testing, that they had seen a "C", an "O", an "S", or an "H", even when there was no prime present. There is high confuseability between these letters and some of the typeface characters. For example, a brief presentation of @ could be confused with O or C, and similarly the $ with S; and the £ with H. Consequently the No Report category included report of one of these confuseable letters as long as that letter did not appear in the prime.

In the following experiment three kinds of relation between prime and target (repetition, associated, unrelated) under binocular masking were studied.

3.6.2. Method

(i) Subjects

Eight female and seven male first year psychology undergraduates participated as part of a a course requirement. All subjects were tested to have 6/6 visual acuity. Ages ranged between 17 and 44 with a mean of 20.6.

(ii) Apparatus

With the exception of the mask the same apparatus and materials as described in Experiment 6 were used, in the same order. The mask was constructed using the following typeface symbols: £ $ % & * @ . On each successive presentation the rightmost character was removed and added at the beginning of the sequence. Using this method each character was presented only once in any one position in every six trials. The mask measured 1.2 in. wide by 0.2 in. high, subtending a horizontal visual angle of 2.7 degrees and vertical angle of 0.45 degrees, when viewed at 26 inches.

(iii) Procedure

Subjects were randomly allocated to one of lists A, B, or C. Once subjects had been tested for acuity, they were seated in front of the screen in the testing room. The experimenter started the program and thereafter the subject controlled the experiment, via the program. In addition to the instructions provided for Experiment 6, subjects were instructed as follows: " Please concentrate on watching the space between the arrows. When you press "Start" you will see a string of symbols followed half a second later by a string of letters. The symbols look like this : - £ $ % & * @". Forty practice trials were followed by 112 Experimental trials with rest periods and knowledge of results as in Experiment 6.

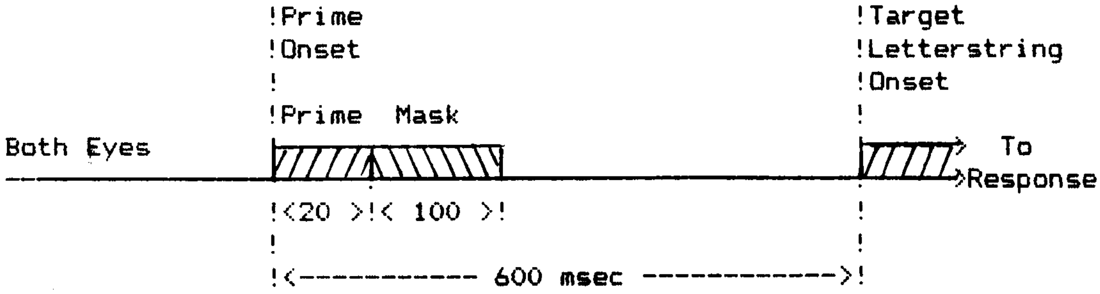


Figure 6

Presentation sequence for Experiment 7

(iv) Presentation Sequence

During the resting phase the two arrows were displayed in the centre of the screen six characters apart. The subject initiated each trial by pressing "START", which was followed by a 500 msec waiting period, then a 20 msec display of the prime word. Immediately on prime offset there was a 100 msec display of the mask, followed by a waiting period (arrows only) until the target, which was displayed until subject response. The prime - target SOA was 600 msec (see Figure 6).

(v) Post Experimental Questioning

The questioning session began with the open ended request to "Please describe the display sequence in as much detail as possible" and continued with structured questions based on this first answer (see Appendix A.8). The use of an open-ended question containing no bias was intended to overcome the possibility of directing the subject towards a particular response. The questions were read from a printed sheet.

3.6.3. Results

(a) "Yes" and "No" responses

Response latencies are shown in Table 8. Error rate was 3.2% for "Yes" responses and 8% for "No" responses. An overall one way within subjects ANOVA was performed on Response (Yes, No) RT's. "Yes" responses were significantly faster than "No" responses (F (1,14) = 109.97, p < .0001). Further analysis is of "Yes" responses only.

Table 8

Mean RT's (msec) by Prime type in Experiment 7

		"Yes" Responses			"No" Responses
	n	Repetition	Associated	Unrelated	Word/Nonword
Report	2	516	522	542	655
No report	13	498	509	516	672

n = number of subjects

Table 9

Priming effects relative to the mean unrelated RT (msec)

	Repetition	Associated
Report	26	20
No report	18	7

(b) Priming Effects (displayed in Table 9)

Only two of the fifteen subjects reported seeing anything attributable to the presence of a prime word. A two way within subjects ANOVA was performed with factors Report (Report/No Report) and Prime type (repetition, associated, unrelated). Report does not significantly affect RT, but the effect of Prime type is significant (F (2,26) = 3.51, p < .05). A separate one way within subjects ANOVA on the 13 No Report subjects indicates that Prime type has a significant effect on target RT (F (2,24) = 4.53, p < .05).

Further individual comparisons revealed that (a) repetition RT is significantly faster than unrelated RT (t (11) = 5.22, p < .001), but (b) the 7 msec difference between associated and unrelated RT's is not significant.

3.6.4. Discussion

The two aims of this experiment were (i) to see whether the presentation conditions would produce effective binocular masking, and (ii) where masking was effective, to see if there was any evidence for nonconscious priming. The two issues will be discussed separately.

(a) Criteria for awareness

Only two out of the fifteen subjects reported seeing all or part of a prime word during the experiment. One of the two subjects who reported, stated that he saw a prime at the end of the first block of trials and a few primes subsequently. The other subject reported, in answer to question two, that he had seen letters and possibly a word, but had only noticed these towards the end of the experiment. There were no other reports, and many subjects expressed surprise that prime words had been presented.

(b) Priming Effects

For those subjects who did not report seeing a prime on any trials, there is evidence for repetition, but not associative, priming when the subject is unaware of the prime. This finding supports the combined results of Experiments 2 and 4 where there was also repetition priming in the absence of associative priming. There is only 18 msec nonconscious repetition priming in the present experiment as compared to 25 msec in Experiment 2. The nonsignificant 7 msec associative priming cannot be explained by peripheral masking because of the significant repetition priming. In the present procedure the No Report criteria rely heavily on the subject's memory, at the end of a total of 152 (practice and experimental) trials. It is possible that subjects were either forgetting that they had seen the prime, or were confused over the temporal sequence. However, it seems unlikely that they had been aware of the prime on many trials, since they were only asked whether they had seen letters or words and not what the letters or words were. Furthermore, any such forgetting cannot explain the absence of associative priming in the presence of repetition priming. Indeed the absence of associative priming supports the subject's retrospective report, since these primes have been shown (Experiment 6) to produce substantial priming when subjects were aware of them. The following experiment investigates priming effects under conditions where subjects are less likely to forget seeing a prime word or letters.

3.7. Experiment 8: Priming without awareness in a binocular LDT where awareness is determined by post-trial subject report.

3.7.1. Introduction

In the following experiment subjects were asked at the end of every trial whether or not they had seen a prime word. The procedure still suffers the weakness that the subjects were not questioned about the presence of the prime until after the LDT response, by which time they have had to perform several operations, and this may cause some interference with memory. Nonetheless the demand on memory is greatly reduced and there is less likelihood that the subjects will forget aspects of the prime of which they had been aware. The change in task requirements is likely to produce a corresponding chance in subjects' attentional strategy. In Experiment 7 subjects were not told that a prime word would be presented. Few if any would be looking for a prime. In other words, their attention was probably directed towards the mask as a warning indicator for the following target. If subjects are asked at the end of each trial "Is there anything other than the mask ?", then they will probably allocate some attentional resources to see if they can detect something else. Such reallocation of resources should produce an increase in the proportion of subjects in the Report category and an increase in the proportion of Report trials overall, compared with the results of Experiment 7. It is possible that changing strategic attention will affect the type and level of processing. Strategies resulting in more intensive or narrowed attention can produce a situation counterproductive to eliciting nonconscious processing, in comparison with the more relaxed and passive approach in the previous experiment (see Marcel, 1983a, Experiment 1; Dixon, 1971). However, a higher degree of confidence can be accepted that "No Report" is veridical for those subjects who state, approximately two seconds after prime presentation, that they did not see anything of the prime word.

The prediction is that there will be an increase in the proportion of "Report" over "No Report" subjects in the following experiment compared with Experiment 7. The question is whether repetition and associative priming will occur under these conditions.

3.7.2. Method

(i) Subjects

Five male and ten female first year psychology students, aged between 18 and 39 years (mean age = 23.4), participated as part of a course requirement. All subjects were tested to have 6/6 visual acuity.

(ii) Apparatus, materials, and order of presentation were the same as in Experiment 7.

(iii) Procedure

The procedure was the same as Experiment 7, except that during the instructions the subjects were told "On some trials there may be something other than the symbols before the letterstring" and they were asked to report back at the end of each trial. If subjects saw something they were to reply "Yes" and state what they saw, or "No" if there was nothing other than symbols. The presentation sequence was the same as in Experiment 7 with the following addition. After the subject had responded on the LDT there was a

100 msec blank screen followed by a 120 msec display of the message: "That was trial £ (x) : was there anything other than symbols?". During practice trials this message appeared after the appropriate feedback messages. The subject's verbal report was recorded by the experimenter via the audio link.

3.7.2. Results

(a) "Yes" and "No" responses

Errors (Misses) were approximately 3.2% for "Yes" responses (words) and did not differ across Prime Type, while for the "No" responses errors were much higher at 8%. The large difference is attributable to the "Yes" response bias generated by the higher probability of occurrence in that category which was not completely counteracted by the error message feedback to subjects. An overall one way within subjects ANOVA of Response (Yes / No) demonstrated that "Yes" responses are significantly faster than "No" responses (F (1,14) = 57.26, p < .0001). Further analysis is of "Yes" responses only.

Table 10(a)

Mean RT's (msec) by Prime Type for Report and No Report subjects in Experiment 8

			"Yes" Responses			"No" Responses
No. Subjects	% Trials		Prime Type Repetition	Associated	Unrelated	Word
11	35	Report	563	584	672	712
11	65	No Report	561	586	594	677
4	100	No Report only	487	513	488	632

Table 10(b)

Target Mean RT's (msec) for Identified and Unidentified Primes in Experiment 8 ("Yes" responses only)

No. Subjects	% Trials		Prime Type: Repetition	Associated	Unrelated
9	22	Prime Identified	522	587	627
9	78	Prime Unidentified	551	574	595
6	100	Prime Unidentified only	517	547	522

(b) Priming Effects (Displayed in Table 11)

A one way within subjects ANOVA on the overall results indicated that the effect of Prime type is significant (F (2,28) = 11.43, p < .001). Results were partialled into Report and No Report trials using the same criteria as in Experiment 7. Criteria for inclusion in the Report category were reports of (i) a word, (ii) letters, (iii) a letter (excluding one "confuseable" letter not included in the prime), and (iv) "something other than symbols. Criteria for inclusion in the No Report category were reports of (i) nothing other than symbols, (ii) one letter which may have been confused with the symbols but was not a prime letter.

Eleven of the fifteen subjects (73%) reported seeing a prime word, or part of it, on at least one trial (36% of trials were Report). Mean RT's for Report and No Report trials were calculated and are displayed in Table 10(a). The mean RT's of the 11 subjects who gave both Report and No Report data were analysed. A two way ANOVA was performed on this data with factors Report (Report / No Report) and Prime Type (repetition, associated, unrelated). Report is not significant but the effect of Prime Type is significant (F (2,20) = 17.35, p < .0001). Priming effects were analysed separately for Report and No Report trials.

Table 11

Priming effects relative to the mean unrelated RT (msec)

	Repetition	Associated
Report	109	88
No Report	33	8
(No Report only)	1	-25
Prime Identified	105	40
Prime Unidentified	44	21
(Prime Unidentified only)	5	-25

(i) Report: The difference in mean RT's between (a) repetition and unrelated targets is significant (t (10) = 6.21, $p < .01$), (b) associated and unrelated targets is significant (t (10) = 3.07, $p < .01$), and (c) repetition and associated targets is not significant.

(ii) No Report: The difference in mean RT's between (a) repetition and unrelated targets is significant (t (10) = 2.71, $p < .05$), (b) repetition and associated targets is significant (t (10) = 3.4, $p < .01$), but (c) between associated and unrelated targets is not significant. If the trials means for the four No Report only subjects are added to the No Report trials of the other 11 subjects, then there is a significant difference between the repetition and unrelated target RT's (t (14) = 2.83, $p < .01$), but no other significant differences.

A separate analysis was performed to see if the means from subjects who gave only No Report differed from the overall means of subjects who gave both Report and No Report. A two way ANOVA with across subjects factor Report (* 2) and within subjects factor Prime Type (* 3) shows that (a) the main effect of Report is significant (F (1,13) = 4.97, $p < .05$), (b) the main effect of Prime Type is significant (F (2,26) = 7.02, $p < .01$), and (c) the interaction is significant (F (2,26) = 3.74, $p < .05$). Further separate analyses of the four No Report mean RT's revealed no significant differences.

(c) Identified versus Unidentified primes

The data was reanalysed on the following basis: (i) the Identified category consisted solely of correctly identified primes, (ii) all reports from reporting "Nothing" up to and including incorrect identification of a prime, were included in an Unidentified category. This reallocation changed the emphasis of the separation, for in this second analysis many subjects were aware of at least part of the prime word in the Unidentified category. Nine of the fifteen subjects could identify a prime word on at least one trial. Mean RT's for Identified and Unidentified were calculated and are displayed in Table 10(b). A two way ANOVA was performed on this data with factors Identification (Identified / Unidentified) and Prime Type (repetition, associated, unrelated). Identification is not significant. The effect of Prime Type is significant (F (2,16) = 22.68, $p < .0001$). Priming effects were analysed separately by Identification condition.

(i) Identified: the difference in RT's between (a) repetition and unrelated targets is significant (t (8) = 4.6, $p < .01$), (b) repetition and associated targets is significant (t (8) = 3.53, $p < .01$), and (c) associated and unrelated targets is not quite significant (t (8) = 1.78; critical value = 1.86).

(ii) Unidentified: the difference in RT's between (a) repetition and unrelated targets is significant (t (8) = 6.62, $p < .001$), (b) repetition and associated targets is significant (t (8) = 2.8, $p < .05$), and (c) associated and unrelated targets is not significant. If the trials means from the six subjects who did not identify a word on any trial are added to the Unidentified trials of the other nine subjects, then the difference between (a) the repetition and unrelated target RT's is significant (t (14) = 3.35, $p < .001$), (b) repetition and associated targets is significant (t

(14) = 4.22, $p < .001$), and (c) associated and unrelated targets is not significant.

A separate analysis was performed to see if the means from the nine subjects who could sometimes identify primes (Identified) differed from the overall means of six subjects who could not (Unidentified). A two way ANOVA with across subjects factor Identification (* 2) and within subjects factor Prime Type (* 3) shows that (a) the main effect of Identification is not significant although (b) the main effect of Prime Type is significant (F (2,26) = 12.95, $p < .001$), and (c) the interaction is significant (F (2,26) = 6.92, $p < .01$). Further separate analyses of the six Unidentified only mean RT's revealed that the only significant difference was between repetition and associated target RT's (t (5) = 3.01, $p < .05$).

3.7.4. Discussion

(a) Criteria for Awareness

Comparison with Experiment 7 reveals, not surprisingly, that the number of subjects who reported seeing at least a few letters of the prime, increased substantially (from 2/15 to 11/15) when subjects were asked to make their decision on a trial by trial basis. However, four subjects did not report seeing a prime at any time during the experiment, and there was still a high proportion of No Report trials for those subjects who reported awareness on some occasions. The distribution of Report and No Report depends partly on the expectations the subjects have of what they are likely to see, and their consequent attentional strategies. Given the problems associated with the critical SOA technique, the present procedure is stronger because it allows for changes in sensitivity and attentional strategies during the experiment, and changes situational demand characteristics by encouraging subject report.

(b) Priming Effects

The priming effects for Report trials (Table 11) shows both repetition and associative priming for the 11 subjects who could report at least something of the prime. However, the associative priming effect for Report trials appears to be partly attributable to inhibition for unrelated primed targets (c.f. Neely, 1977). No Report data provided by the same subjects shows a large and significant repetition priming effect, but only a small and nonsignificant associative priming effect. There was no associative priming effect for those subjects who never reported primes, indeed associative primed targets were responded to slower than unrelated targets.

Results reallocated on the basis of correct / incorrect prime identification provides the same pattern of priming. Reallocation includes reports of (a) incorrectly identified words, (b) letters (correct or incorrect), and (c) "something", as one category (Unidentified). This category includes a high degree of partial cue information. The failure to produce associative priming in the prime Unidentified category implies that partial cue information has only a marginal affect on nonconscious associative priming. It is worth noting that the priming effects (Table 11) appear to be selective. Under all conditions associative priming is always less than repetition priming.

The occurrence of nonconscious repetition priming in all conditions shows that the failure to obtain nonconscious associative priming cannot be due to complete peripheral masking. There is considerable evidence for some peripheral masking under binocular presentation (e.g., Turvey, 1973), although Marcel (1983a) claims nonconscious associative priming in several experiments where presentation was binocular. If some contribution from peripheral masking is assumed in the present experiments, then prime information will be partially degraded. Under these conditions processing of this minimal information could be sufficient to provide raised activation facilitating a following repetition target, but insufficient to facilitate an associated target.

3.8. Experiment 9: Priming without awareness in a dichoptic LDT where awareness is determined by post-trial subject report.

3.8.1 Introduction

Dichoptic presentation ensures central masking (Turvey, 1973; Marcel, 1983a). According to Turvey's (1973) analysis central masking operates by interruption rather than integration (Kahneman, 1967). This may allow a nondegraded representation and provide sufficient information for nonconscious associative priming. The outcome of the earlier pilot studies using the critical SOA technique was that effective dichoptic masking was only obtained for small stimuli. These conditions produced no evidence for nonconscious repetition priming (Experiment 1). Informal testing using the display conditions used in Experiment 8, except with dichoptic presentation of target and mask, provided effective masking for most subjects. Comparison of results from Experiments 7 and 8 shows that the proportion of Report trials increases when subject's attention is drawn to the fact that a prime might be present. The optimum situation would be to maximise the number of No Report subjects, by using the post experimental report strategy. However post-trial report has the advantage that it places less demand on subject's memory, and should therefore produce a more reliable result. The following experiment was designed to be as similar as possible to Experiment 8 to allow close comparison of results. If partial peripheral masking is the reason why no associative priming has been found, then it should occur with dichoptic presentation.

3.8.2. Method

(i) Subjects

Eight female and seven male psychology undergraduates, mainly first year, participated as part of their course requirement. Their ages ranged from 19 to 36 with a mean age of 22.6. Only subjects tested to have 6/6 vision were accepted into the experiment.

(ii) Apparatus

The same microcomputer apparatus was used as described for Experiment 7, but with one major addition. A mirror stereoscope was constructed based on a design described by Sperling (1970).

(iii) Stimuli were the same and presented in the same order as in Experiment 8.

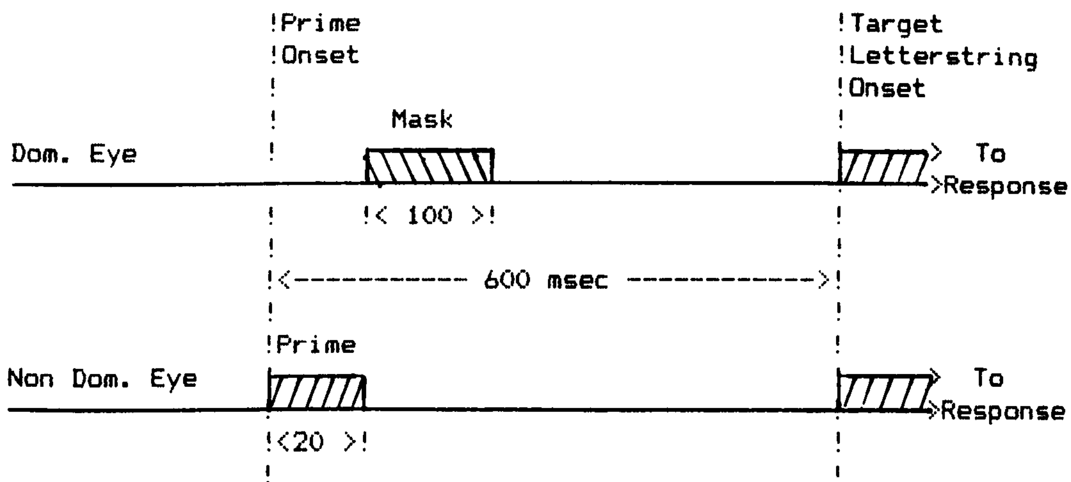


Figure 7

Presentation sequence for Experiment 9

(iv) Procedure

The VDU screen was split and treated as two separate screens. Some reformatting of the feedback messages was necessary, but the messages presented essentially the same information as in Experiment 8. Subjects were tested for visual acuity using the Lizar's eyesight test card, and then tested for eye dominance using the modified version of the aligning technique in a procedure fully described in Experiment 1. Subjects were presented with the same instructions as in Experiment 8, on a separate screen. They were then seated at the stereoscope and adjustments were made for comfort. Two squares were presented in the centre of each half of the screen, and subjects were asked if they saw one clearly defined square. The results of informal experimentation had provided a convergence setting for the two sets of mirrors such that it rarely needed adjustment. The rest of the procedure was the same as in Experiment 8. The presentation sequence is displayed in Figure 7.

3.8.3. Results

(a) "Yes" and "No" responses (see Table 12)

Errors (misses) were approximately 2% for 'Yes' responses (words) and did not differ across Prime type. Errors were much higher for the 'No' responses at 8%. An overall one way within subjects ANOVA was performed on Yes/No Response. "Yes" responses were significantly faster than "No" responses (F (1,14) = 93.54, $p < .0001$). Further analysis is of "Yes" responses only.

Table 12

Subject mean RT's (msec) by Prime type in Experiment 9

		"Yes" Responses			"No" Responses
	n	Repetition	Associated	Unrelated	Word/Nonword
Report	5	528	520	582	679
No report	10	595	605	622	719

n = number of subjects.

(b) Priming Effects (see Table 13)

Results were partialled into Report and No Report trials using the same criteria as in Experiments 7 and 8. Five of the fifteen subjects reported seeing a prime word, or part of it, on at least one trial (29% of trials were Report). Only three of these five subjects provided both Report and No

Report data, one subject provided data in both categories but not under all conditions, one subject provided only Report data on all trials. The remaining ten subjects provided only No Report data.

Table 13

Priming effects relative to the mean unrelated RT (msec)

	Repetition	Associated
Report	54	62
No report	27	17

The mean RT's of the three subjects who gave both Report and No Report data were analysed. A two way ANOVA was performed on this data with factors Report (Report / No Report) and Prime Type (repetition, associated, unrelated). There were no significant differences.

A separate analysis was performed to see if the means from subjects who gave only No Report differed from the overall means of subjects who gave both No Report and Report, or Report only. Mean RT's for these two groups are displayed in Table 12. A two way ANOVA with across subjects factor Report (* 2) and within subjects factor Prime Type (* 3) shows that (a) the main effect of Report is not significant, (b) the main effect of Prime Type is significant (F (2,26) = 17.9, $p < .0001$), and (c) the interaction is significant (F (2,26) = 4.28, $p < .05$). Report and No Report means were analysed separately.

(i) Report: The difference between (a) repetition and unrelated RT's is significant (t (4) = 3.91, $p < .01$), (b) associated and unrelated RT's is significant (t (4) = 3.88, $p < .01$), but (c) there was no difference between repetition and associated target RT's.

(ii) No Report: The difference between (a) repetition and unrelated RT's is significant (t (9) = 2.59, $p < .05$), (b) the difference between associated and unrelated RT's is significant (t (9) = 3.2, $p < .05$), but (c) there was no difference between repetition and associated target RT's.

3.8.4. Discussion

The most important finding is the appearance of nonconscious associative priming. This suggests that binocular peripheral masking was present and may have prevented associative facilitation in the earlier experiments. Nonconscious associative priming of 17 msec is small compared with the results from similar experiments (Fowler et al., 1981; Marcel, 1983a; de Groot, 1983). These differences may be attributable to stimulus sets and/or details of masking characteristics. The difference in the nonconscious associative priming effect between Experiment 7, 8 and 9, provides support for Chambers (Note 9) claim that dichoptic presentation is "critical" (Marcel, 1983a, footnote p.232) in obtaining associative priming effects.

3.9. Discussion of Priming without awareness in the Lexical Decision Task.

The outcome of the work described in Chapter Two was that there are serious weaknesses in the critical SOA procedure as a stable measure of a detection threshold. Nonconscious repetition priming was obtained in a procedure designed to overcome some of these weaknesses (Experiment 2). There was no evidence for nonconscious associative priming using the critical SOA technique (Experiments 3 and 4). A series of experiments was designed to improve various aspects of Marcel's procedure for investigating nonconscious LDT priming (Experiments 5 to 9). Two further attempts to demonstrate nonconscious associative priming under binocular pattern masking conditions were unsuccessful (Experiments 7 and 8). The robust nonconscious repetition priming effect in the same experiments indicates that this failure could not be due to complete peripheral masking. The results of Experiment 9 demonstrate that nonconscious associative priming can be obtained dichoptically. Comparison with other experiments in this area is difficult because of (a) small but nontrivial differences in procedure and criteria for assessing awareness, and (b) different patterns of nonconscious priming effects. These two aspects will be discussed separately.

(a) Criteria for awareness

In Experiments 7 to 9 prime and mask presentation conditions were such that most subjects detected only a few of the primes, whether report was post-trial or post-experimental. A few subjects were able to detect a high proportion of the primes. The principal criterion for determining lack of awareness was the subjects' report that there was nothing other than the mask before the target letterstring. A more detailed consideration of the reliability of subject report under these conditions will be presented in Chapter Five. Evidence for nonconscious or automatic processing in other similar experiments is on the basis of criteria which range from (a) inability to accurately detect the prime (Marcel, 1983a; Fowler et al., 1981; Carr et al., 1982; Diaper, Notes 1 and 2), to (b) all reports of letters other than the correct word (Evett and Humphreys, 1981; de Groot, 1983). These criteria are used to label categories variously as (a) "subthreshold" (Fowler et al., 1981; de Groot, 1983), (b) "zero threshold" (Carr et al., 1982), or (c) "No Report" (Diaper, Notes 1 and 2). Allocation to these categories may (a) follow an earlier detection task in a two task paradigm (Marcel, 1983a; Fowler et al., 1981; Diaper, Notes 1 and 2), or (b) be assigned on a post-trial or post-experimental basis (de Groot, 1983; Evett and Humphreys, 1981; Humphreys et al., 1983; Humphreys et al., 1984).

(b) Priming Effects

Adopting these different criteria for awareness produces different patterns of nonconscious priming. In addition the mode of presentation appears to be particularly important, although even under dichoptic presentation nonconscious associative priming effects can still be unpredictable. For example, Fowler et al. (1981), in a dichoptic LDT, failed to replicate a nonconscious associative priming effect obtained at 2000 msec SOA when SOA was reduced to 200 msec. De Groot, (1983) on the other hand, did obtain nonconscious associative priming in a binocular LDT where SOA was 240 msec. In the latter experiment less restrictive criteria were used to determine lack of awareness. According to Chambers (Note 9), dichoptic presentation is "critical" to obtaining nonconscious associative priming. However Marcel (1980, 1983a) demonstrates nonconscious associative priming in several binocular LDT experiments. Carr et al. (1982, p.767) suggest that such inconsistencies between experiments may arise:

> When relatively small amounts of activation occur from a prime, the influence of that activation may be more difficult to observe in the processing of word targets than in the processing of picture targets, creating a situation in which one study of words might find positive results and another might find negative results even though activation from subthreshold primes actually occurred in both studies.

The present experiments demonstrate that nonconscious associative priming effects were only significant under dichoptic presentation. However, for No Report subjects in the Mask conditions in the present experiments, associated targets were always responded to faster than unrelated targets but slower than repetition targets. If any nonconscious associative priming was present it was always smaller than the repetition priming and was very fragile.

CHAPTER FOUR

Priming of Anagram Solutions with and without Awareness

4.1. Introduction

The preceding experiments demonstrate that nonconscious associative priming can significantly affect lexical decision time, but only under dichoptic presentation. One major weakness in using the lexical decision task is the small size of the priming effects. Further work on nonconscious priming investigates priming of anagram solving. Differences in solution times attributable to conscious priming can be measured in terms of seconds rather than milliseconds. Large conscious associative priming effects were expected to allow statistically significant evidence for nonconscious associative priming under binocular presentation. In addition this particular task was chosen in order to (i) investigate the effect of nonconscious priming on retrieval of words from semantic memory, and (ii) to examine the relevance of nonconscious processing to complex problem solving tasks.

The prior presentation of the solution or a word associated with the solution produces large conscious priming effects in anagram solving (Dominowski and Ekstrand, 1967; Schuberth, Spoehr and Haertel, 1979; LeMay, 1972; Jablonski and Mueller, 1972). The effect of masked and nonmasked primes on anagram solution times is investigated in the following experiments.

Several authors (Schuberth et al., 1979; Mendelsohn, 1976; Mendelsohn and O'Brien, 1974) suggest that two sequential stages are involved in anagram solving; (i) the letters are rearranged to form a possible solution, and (ii), the rearranged letters are compared with internal representations in semantic memory. The anagram solving procedure continues within this loop until a successful match is obtained. Any factor which restricts or reduces the potential set from which the solution is retrieved can be considered as a cue. Cues operate at both stages as heuristics facilitating retrieval of the solution word, producing a reduction in solution time.

(a) Unprimed anagram solving

The first stage of reordering letters is affected by cues, some of which are already present in the structural or orthographic rules of the language. The following first stage factors are known to influence anagram solution time; (i) word length (Dominowski, 1966), (ii) number of letter moves from anagram to solution (Dominowski, 1966), (iii) uncommon letters such as J, K, Q, U, X, Z (Cohen, 1968), (iv) the transitional probabilities of bigrams and trigrams (Mayzner and Tresselt, 1962, 1966; Mendelsohn and O'Brien, 1974), (v) consonant-vowel patterns (Mendelsohn, 1976), and (vi), the number of vowels overall (Mendelsohn, 1976). Several potential words or word units are generated on the basis of these structural characteristics (Underwood and Schultz, 1960) and matched against stored representations in order of word frequency (Dominowski, 1967; Mendelsohn and O'Brien, 1974; Warren and Thompson, 1969). At the second stage of retrieval there is some evidence that anagram solutions are faster for high frequency solutions than for low ones (Dominowski, 1967; Warren and Thomson, 1969; Mayzner and Tresselt, 1958). However in other studies (Mendelsohn and O'Brien, 1974; Schuberth et al., 1979) solution word frequency was only a marginal predictor of solution times. The claim that imageability facilitates retrieval (Jablonski and Mueller, 1972; Dewey and Hetherington, 1974), has not been supported by Gilhooley and Johnson (1978).

(b) Primed anagram solving

Several authors refer to priming by the anagram solution as "Direct priming" (Dominowski and Ekstrand, 1967; Schuberth et al., 1979; Jablonski and Mueller, 1972). In the present experiments it will be called "solution priming". Dominowski and Ekstrand (1967) investigated the relative effects of conscious solution and associative priming on anagram solution times. Their study involved two parts. In part one subjects were shown one of three lists of words which contained either (a) solutions, (b) associates, or (c) words inappropriate to the anagram solution. In part two subjects were allowed 120 seconds to provide a verbal solution to an anagram. Dominowski and Ekstrand found that priming by either the solution or its close associates significantly decreased solution time compared with either unprimed or inappropriately primed anagrams. The priming effect was significantly greater for solution primed than associatively primed anagrams. There was also "suggestive evidence" that association strength was positively correlated with decrease in solution times. Jablonski and Mueller (1972) replicated the solution priming effect but not the associative priming effect. They suggest that their failure to show associative priming may be due to differences in association strength between the two studies. However, there may be other factors. For example, associative priming in the LDT is known to be affected by intervening items (Dannenbring and Briand, 1982; Davelaar and Coltheart, 1975). The effect of intervening items on repetition priming in a LDT is small. These LDT findings may be generalisable to anagram solving. Comparison between Jablonski and Mueller's study and that of Dominowski and Ekstrand indicate that in the former study (i) association strength between prime and solution was weaker, (ii) there were additional intervening items in the form of instructions, between prime and anagram presentation, and (iii) there were fewer observations in Jablonski and Mueller's study. There are several demonstrations that category priming also decreases solution time (Safren, 1962; Schuberth et al., 1979; Dewing and Hetherington, 1974). Schuberth et al. found that category name priming was more effective for high exemplars of a category than low exemplars.

Most authors (Schuberth et al., 1979; LeMay, 1972; Warren and Thompson, 1969) agree with Mendelsohn (1976) that: "Fundamentally the solution of anagrams is a retrieval problem, ie, the subject's task is to retrieve a word which is already in memory" (p.641). Safren (1962) suggested that priming is produced through a restriction on the pool of words from which a solution is to be retrieved. Dominowski and Ekstrand (1967) argued that priming by associates produces differential availability for solution words. Schuberth et al. (1979) described their category priming results within Collins and Loftus (1975) model of semantic memory. According to this model word priming produces spreading activation to associatively related nodes which then facilitates subsequent retrieval. Activation spreads from the node representing the prime word along association pathways "in an amount that is inversely proportionate to the distance traversed" (Schuberth et al., 1979, p.606). Schuberth et al. attribute the positive relation between decrease in solution time and strength of association in their experiment to differential levels of activation for associated nodes, where level of activation is determined by semantic distance. A similar explanation was offered for the overall results of the LDT experiments (Chapter Three). However, anagram solving is probably a complex multi-facetted process with priming acting in a number of different ways. Solution priming could be the product of cumulative effects at the level of (i) feature analysis, (ii) orthography, (iii) the visual whole word lexicon, (iv) the phonological lexicon and (c) the semantic system. Same case solution priming however can be sufficently explained by activity at feature level only. On the other hand, associative priming of the anagram solution suggests effects operating primarily at semantic level. There may also be a minimal contribution from orthographic or feature priming if the same letter(s) occur in both prime and anagram.

There have been no attempts so far to assess the relative contribution of automatic or nonconscious processing and conscious attentional processes to anagram solving. For example, it is possible that in the first stage of anagram solving, letter recombination is a conscious limited capacity process. However, knowledge of the orthographic rules which facilitate recombination is probably retrieved automatically.

The aims for the following series of experiments are (1) to demonstrate conscious solution and associative priming effect in anagram solving and (2) to use these results to investigate nonconscious solution and associative priming using pattern masked primes.

4.2. Experiment 10: The effect of conscious priming on anagram solution times.

4.2.1. Introduction

The following experiment investigates the effect of three different priming conditions on anagram solution times. The priming conditions are (i) the solution, (ii) a first associate of the solution, and (iii) an unrelated word. The experimental procedure differs from that used by previous investigators (Dominowski and Ekstrand, 1967; Jablonski and Mueller, 1972) in several ways, (i) priming is by trial rather than previous exposure to a word list, (ii) subjects are not informed of prime-anagram relationships, and (iii) an unrelated condition was used to determine priming effect rather than an unprimed or inappropriate condition. The hypothesis is that the effect of the three priming conditions should provide results similar to those of Dominowski and Ekstrand (1967).

Preliminary studies demonstrated that anagram solving was seen as quite threatening by some subjects, although others seemed to derive great pleasure from it. The latter factor was a bonus. The former posed problems. Several people refused to continue after they failed to solve some of the anagrams. These subjects saw the task as a covert intelligence test, and considered themselves disadvantaged because they neither particularly enjoyed anagram solving nor had much practice at it. Several authors (Dixon, 1971; Marcel, 1983a) have commented that nonconscious processes are most in evidence when the subject is in a relaxed or passive mood. A situation which makes some subjects feel threatened and anxious may therefore hinder nonconscious processing.

Several measures were taken to make the task more acceptable and less threatening. First, all subjects were specifically informed that the task was in no way an intelligence test, and a wide range of ability, from very good to very poor, was needed for the experiment. Second, the first three anagrams in the practice set were designed to be particularly easy; the other 15 practice anagrams adequately reflected the difficulty of the experimental set. Third, the experimental situation was made more comfortable by providing a soft chair and hand held switch for the subject. Fourth, subjects were specifically asked not to be discouraged if they couldn't solve an anagram, but to keep trying until "time up".

4.2.2. Method

(i) Subjects

Six female and nine male first year psychology undergraduates took part in the experiment as part of course requirements. Their ages ranged from 18 to 26 with a mean of 20. All subjects were tested to have 6/6 vision using a Lizar's eyesight test card.

(ii) Apparatus

The same apparatus was used as for Experiments 5 to 9, except that a Voice Key was interfaced with the interrupt timing card. The subjects verbal response was relayed to the Voice Key timer, via a microphone. The microphone was also connected to the Experimenter's headphones.

(iii) Prime and Anagram pairs

The word set consisted of 39 pairs of high-association concrete nouns. The word set is fully described in Appendix A.10. Some were used in Experiments 6 to 9. Word length varied between 3 and 6 letters. Word size and visual angles were as detailed for Experiment 5 (Section 3.4.2(iii)).

Overall word frequency varied between 3 and 1772 per million, with a mean frequency of 102. Solution word frequency varied between 10 and 1772 per million (Kucera and Francis, 1967). Mean solution word frequency was 113.4. Prime word frequency varied between 3 and 1207 per million, with a mean of 91.3. In the associated condition primes were all first associates of the solution. Mean association strength between prime and solution word was 43% (Bousfield et al., 1961). The unrelated prime words were matched with the associated primes for word length, word frequency, part of speech, concreteness, and number of close associates. Three lists were constructed such that each of the 39 anagrams received three different priming conditions (solution, associated, unrelated). For example if in List A an anagram was preceded by its associate, it would be preceded by the solution in List B, and by an unrelated word in List C. Thus a solution time was obtained for each anagram when primed by (a) the solution, (b) the first associate, and (c) an unrelated word. Order of presentation was randomized for List A. The same random order was used to present the anagrams in Lists B and C. A practice set of 18 word pairs, six for each of the priming conditions, was constructed. Word frequency and association strength were comparable. Anagrams were produced nonsystematically from the target words. Constraints avoided successions of three letters in the same sequence as the solution, or any letter appearing in the display in the same position as the solution. Highly informative bigrams or trigrams (e.g., ph, th, or sch) did not appear. The anagrams varied considerably in difficulty, from easy ones with three letter (e.g., of cow) to quite difficult six letters anagrams (e.g., of saucer). The intention was to keep the problem set easy enough for most people to solve.

(iv) Procedure

Subjects were randomly allocated to list, and seated in the testing room in front of the VDU. The experimenter started the program and thereafter the subject retained control of the experiment until it had finished. The first part of the program provided the experimental instructions. These are given in detail in Appendix A.11. In brief, subjects were given a definition and examples of anagrams. They were told that a word would be presented followed by an anagram. The task was to solve the anagram as quickly as possible and speak the answer into the microphone. Subjects were told that (a) they had 60 seconds to solve the anagram, (b) the solutions were all common nouns, (c) there may be several solutions to each anagram, (d) one solution would be provided after the subject's response, (e) a solution would be presented if they did not solve the anagram within 60 seconds. Subjects were advised not to worry if they had a correct solution to the anagram which was different to the one presented at the end of the trial. No explicit instructions were given about the relationship between prime and anagrams in this experiment as they would not be appropriate in subsequent experiments. Subjects were expected to recognise the relationships between prime and solution in the practice trials. There were 18 practice trials followed by a two minute pause, or longer if the subject had any questions or comments. A message inviting these was displayed on the screen. The 39 experimental trials were presented in two blocks (20 and 19), with a 2 minute pause in between. At the end of the experiment subjects were thanked for their help. Comments or criticisms of the experiment were invited.

(v) Presentation sequence

Presentation sequence was similar to Experiment 6 (600 msec condition), except that response requirements were different. During the resting phase and inter-trial interval two arrows were displayed 1.25 in. apart in the centre of the screen. All stimulus displays occurred between the arrows. The subject initiated each trial by pressing the hand-held "Start" button. A 500 msec pause was followed by a 500 msec display of the prime word, then a 100 msec display of arrows only until the anagram was displayed. The anagram was displayed until the subject's response or 60 seconds, whichever was the sooner. The anagram was replaced by the expected solution and the solution time which were displayed for two seconds. The display then reverted to the resting phase (arrows only).

4.2.3. Results

Incorrect solutions, together with solutions which were valid but not the required solution, are termed "Exclusions". Anagrams unsolved at 60 seconds are termed "Misses". Misses and Exclusions are excluded from the main analysis. Solution times for "Correct" solutions, percent Misses and Exclusions are given in Table 14. The analysis is presented in two parts. First, the number of anagrams solved within (i) 60 seconds, and (ii) three seconds. Second, analysis of the mean solution times of those anagrams solved within 60 seconds.

Table 14

Conscious anagram priming by solutions and associated words in Experiment 10

	Priming Condition		
	Solution	Associated	Unrelated
Mean Solution Time (secs)	1.2	2.2	6.6
Mean number Solved (Max=13)	12.3	11.9	10.7
Misses (% Condition)	3.1	3.6	10.8
Exclusions (% Condition)	2.1	5.1	6.7

(a) Analysis of number of anagrams solved

(i) Within sixty seconds: A one way within subjects ANOVA shows that the effect of Prime Type is significant (F (2,28) = 10.52, $p < .001$). Separate analyses reveal that the difference in the number of anagrams solved between (a) solution and unrelated priming conditions is significant (F (1,14) = 18.1, $p < .001$), (b) associated and unrelated priming conditions is significant (F (1,14) = 15.2, $p < .01$), but (c) the difference between solution and associated priming is not significant.

(ii) Within three seconds: the majority (79%) of Solution primed anagrams were solved in the first three seconds compared with 32% of unrelated primed anagrams. A one way within subjects ANOVA shows that the effect of Prime Type is significant (F (2,28) = 80.31, $p < .0001$). Separate analyses reveal that the difference in the number of anagrams solved between (a) solution and unrelated priming conditions is significant (F (1,14) = 172.1, $p < .0001$), (b) associated and unrelated priming conditions is significant (F (1,14) = 70.7, $p < .0001$), and (c) the difference between solution and associated priming is also significant (F (1,14) = 14.4, $p < .01$). Furthermore, the number solved within the first second also differs widely across priming condition. Across all subjects 108 (55%) of solution primed anagrams were solved compared to only one (0.5%) unrelated, and 40 (21%) associated primed anagrams.

(b) Mean solution times

A one way within subjects ANOVA shows that the effect of Prime Type is significant (F (2,28) = 32.55, $p < .0001$). Separate analyses reveal that the difference between (a) solution and unrelated priming conditions of 5.4 seconds is significant (t (1,14) = 5.62, $p < .001$), (b) associated and unrelated priming conditions of 4.4. seconds is significant (t (1,14) = 4.28 $p < .001$), and (c) the difference between solution and associated priming of one second is also significant (t (1,14) = 3.09 $p < .01$).

4.2.4. Discussion

Most people were able to solve most of the anagrams within the 60 second time limit. However the number of anagrams solved was affected by the prime-solution relationship. When subjects were given the solution to the anagram they solved 82% of the anagrams. Only 79% of associated primed and 71% of the unrelated primed anagrams were solved. There were several solutions to some of the anagrams even though considerable effort had been expended in trying to select only single solution anagrams. This is almost impossible when attempting to keep all the other factors such as word frequency, concreteness, part of speech, and association strength balanced. The results provide strong support for Dominowski and Ekstrand's (1967) findings but are contrary to those of Jablonski and Mueller (1972) who failed to find associated priming effects.

The aim of this experiment was to provide a task where lexical access was assured. The results show that if people are given the solution to an anagram they can solve it in about 1/5 the time it takes compared with when no help is given. Furthermore, given the solution they can solve the anagram in approximately half the time compared with when they are given a clue. The one second difference between the two related conditions (solution and associated) is less significant than the comparison between either of these related conditions when compared to the unrelated condition. The faster solution times for the two related conditions could reflect contributions from both limited capacity attentional processes and from automatic processes. The similarity between the solution and associated solution times under the present conditions is worth bearing in mind when reviewing the results of the following experiments. The long solution time for the unrelated condition may be due partly to interference from inappropriate attentional strategies, in addition to the lack of help in solving the anagram.

The assumption is made that subjects are aware of prime-solution relationships. The following strategy for solving anagrams in the present experiment was suggested by several subjects. The first strategy is rearranging letters to see if they match with the prime. If this fails associates of the prime are generated. These associates provide a larger but still restricted retrieval set for matching. Subjects know that the solutions are all concrete and familiar nouns of between three and six letters. If rearranged letters fail to match with associated words then the routine of reorganising letters and attempting matches continues. This routine treats the anagram as if it were unprimed. The final procedure is considerably delayed by the previously attempted but unsuccessful strategies. This suggested sequence of operations is supported by the ratio of the number of anagrams solved in the first three seconds. Less than half of the number of unrelated compared with solution primed anagrams were solved by this time. Exactly half the number of unrelated compared with associated anagrams were solved. The higher number of solution and associated anagrams solved within the first second may also indicate a fast acting automatic process (Posner and Snyder, 1975). It was not possible to separate automatic from limited capacity processes in the present experiment. The following experiment was designed to investigate the contribution of nonconscious automatic processes on anagram solution times. The anagram solving task is strongly influenced by priming and provides a wide separation between priming conditions. The following experiment investigates whether solution and associative priming are still effective when the prime word is masked to prevent awareness.

4.3. Experiment 11: Priming without awareness in anagram solving, where awareness is determined by post-experimental subject report of binocularly masked primes.

4.3.1. Introduction

The aim of the following experiment was to use the materials and basic procedure of Experiment 10, but in addition, to render the prime word unavailable to consciousness using the masking procedure described in Experiment 7. In Experiment 7 nonconscious priming effects were very small and the variance across subjects may have obscured statistical significance of results. The large priming effects in Experiment 10 may increase the chances of obtaining significant nonconscious associative priming if it should occur. In order to maximise the chances of eliciting nonconscious associative effects the prime word presentation parameters used in Experiment 7, which provided 86% No Report subjects, were adopted for the following experiment.

4.3.2. Method

(i) Subjects

Nine female and six male first year psychology undergraduates participated as part of a course requirement. Their ages ranged between 17 and 22 with a mean age of 19. All subjects were tested to have a minimum of 6/6 vision.

(ii) Apparatus

Materials and apparatus was the same as in Experiment 10, with the addition of the pattern mask fully described for Experiment 7 (Section 3.6.2(ii)).

(iii) Procedure

The procedure was the same as in Experiment 10 with additional instructions to account for the presence of the pattern mask. The presentation sequence, similar to Experiment 7, is represented in Figure 8.

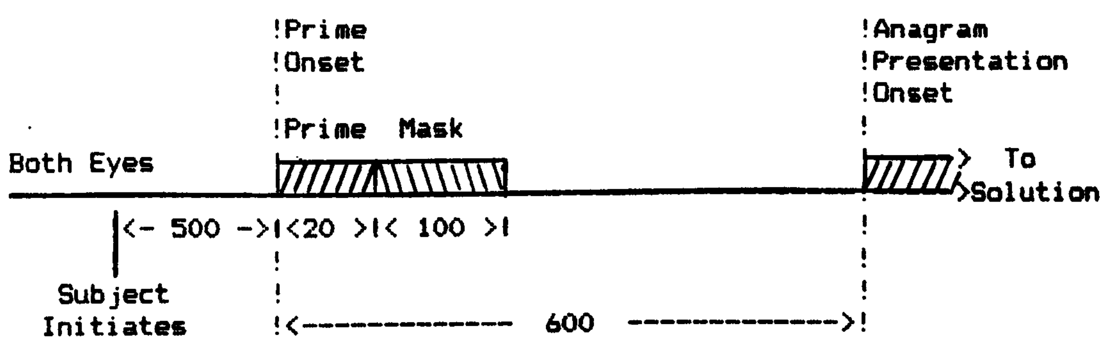


Figure 8

Presentation sequence for Experiment 11 (time in msec)

Subjects were presented with five pages of instructions, given in detail in Appendix A.12. Briefly, they were given a definition and examples of anagrams. They were told that two arrows would be presented in the centre of the screen and they were asked to "concentrate on watching the space between the arrows". When they pressed start "a string of symbols would appear followed half a second later by an anagram". The subjects were asked to "watch the sequence carefully as the symbols would warn them that the anagram was about to appear". They were told that "all solutions would be common nouns and were asked to solve the anagram as quickly as possible, speaking the answer out loud". The voice key relay system picked up their answer and stopped the interrupt timer in the computer. Other instructions, attempting to alleviate subjects worries about the task and to induce them to relax, were the same as in Experiment 10.

There were 18 Practice trials followed by a two minute pause, then 39 Experimental trials in two blocks with a two minute relaxation period intervening. At the end of the experimental trials subjects were asked the same series of questions as in Experiment 7 (see Appendix A.8), and thanked for their participation.

4.3.3. Results

Solutions which were valid but not the required solution, together with incorrect solutions, are termed "Exclusions". Anagrams unsolved at 60 seconds are termed "Misses". Both were excluded from the main analysis. Solution times for "Correct" solutions, percent Misses and Exclusions are given in Table 15 below. Subject results were allocated to a Report or No Report category subsequent to the post experimental questioning using the same criteria as in Experiment 7. There were five Report subjects and ten No Report subjects. Mean solution times, mean number of anagrams solved, Misses and Exclusions, are given in Table 15. Statistical analysis follows the same procedure as in Experiment 10.

Table 15

Anagram priming by backward masked solution and associated primes in Experiment 11

	Priming Condition		
	Solution	Associated	Unrelated
Report			
Mean Solution Time (secs)	2.6	5.1	6.1
Mean number Solved (Max=13)	12	10.2	10.6
Misses (% Condition)	1.5	10.8	15.4
Exclusions (% Condition)	6.2	10.8	3.1
No Report			
Mean Solution Time (secs)	4.1	5.5	6.3
Mean number Solved (Max=13)	11	10.6	10.8
Misses (% Condition)	7.8	9.1	9.1
Exclusions (% Condition)	7.8	8.5	6.9

(a) Number of anagrams solved

(i) Within sixty seconds: A two way ANOVA with across subjects factor Report (Report, No Report) and within subjects factor Prime Type (solution, associated, unrelated) shows that the main effect of Prime Type is significant (F (2,26) = 3.79, p < .05). The main contributor to this effect was the difference between the number of solution and unrelated anagrams solved (F (1,14) = 4.3, p < .05).

(ii) Within three seconds: A two way ANOVA with across subjects factor Report (Report, No Report) and within subjects factor Prime Type (solution, associated, unrelated) shows that the main effect of Prime Type is significant (F (2,26 = 18.88, p < .0001). Further analysis shows that (a) the difference between the number of solution and associated primed anagrams solved is significant (F (1,14) = 35.7, p < .0001), (b) there was no difference between the numbers of associated and unrelated anagrams solved.

(b) Mean solution times

A two way ANOVA with across subjects factor Report (Report, No Report) and within subjects factor Prime Type (solution, associated, unrelated) shows that the main effect of Prime Type is significant (F (2,26) = 6.7, p < .01). There were separate analyses for Report and No Report subject means:

(i) Report: the difference in solution time between (a) solution and unrelated primed anagrams is significant (t (4) = 3.4, p < .05), (b) solution and associated primed anagrams is only marginally significant (t (4) = 2.49, p < .05 1 tailed).

(ii) No Report: the only significant difference is between solution and unrelated primed anagrams (t (9) - 2.81, p < .05).

Further analyses were performed to ascertain the most appropriate statistical method for analysing the present results. There was a remarkable concordance in the results of these analyses. In the No Report category it made little difference whether analysis was by (a) number solved, either at 60 seconds or at three seconds, (b) mean solution times with or without Misses included, (c) median solution times, or (d) Mann-Whitney scores for the means with Misses included. All these analyses show that in the No Report category there is a significant difference between the solution and unrelated condition, but not between the associated and unrelated condition.

4.3.4. Discussion

(a) Criteria for awareness

The problem with post-experimental report is that intervening tasks may interfere with subjects' ability to correctly recall whether or not they had seen a prime word. This problem has already been discussed with reference to Experiment 7. There may be a greater likelihood of correct recall in the present experiment, for several reasons. First, there are fewer experimental trials in this experiment (39 compared with 132), and therefore possibly less interference. Second, awareness of a prime word related to an anagram solution is likely to be a more memorable event than the prime in a LDT. These two factors may explain why there is a higher proportion of Report subjects in the present experiment (5/15) compared with Experiment 7 (2/15).

(b) Priming effects

Several salient points emerge from this experiment. First, priming effects from No Report subjects are assumed to reflect nonconscious processes within the given criteria for awareness. Nonconscious solution priming of 2.2 seconds is substantial and highly significant. Second, although nonconscious associative priming is smaller (0.8 sec) and non-significant, it is in the predicted direction. Third the non-significant associative priming cannot be due to complete peripheral masking because there is significant solution priming under the same masking conditions. Earlier experiments on the LDT suggested a contribution from peripheral masking. Nonconscious associative priming has been demonstrated under dichoptic central masking (Experiment 9; Marcel, 1983a; Fowler et al., 1981). Two reasons are put forward for continuing with binocular presentation, (a) the low ecological validity of dichoptic presentation to studies of reading and visual perception in general, and (b) several studies have demonstrated that nonconscious associative priming can occur under binocular presentation (Marcel, 1983a; Evett and Humphreys, 1981). If failure to obtain nonconscious associative priming is due to some contribution from binocular peripheral masking then increasing the prime duration may overcome some of the peripheral effects. The following experiment investigates this possibility.

4.4. Experiment 12: The effect of increasing prime duration on priming without awareness in anagram solving, where awareness is determined by post experimental subject report.

4.4.1. Introduction

The problem addressed in the following experiment is how to make a masked prime more available for nonconscious processing. This problem has already been discussed prior to Experiments 7 and 11. Backward masking is only effective for a 20 msec prime followed immediately by a 100 msec mask. If prime duration or SOA are increased then mask effectiveness is seriously impaired. Uttal's (1969a,b) dynamic visual noise experiment on the combined effects of forward and backward masking offered the possibility of a solution to this problem. Forward and backward masks presented independently produced masking interference up to 30 msec SOA. When both masks were used together, masking was effective up to 75 msec SOA for each component. Uttal suggested that the two masks did not operate independently. The increase in mask effectiveness was due to an interaction produced by "Some unknown psychobiological process (which) may have extended the time constants of the effects." (p.180). Informal testing for the present experiment, using backward and forward masks, showed that it was possible to increase prime display time considerably and maintain effective masking. It is difficult to determine the degree of peripheral masking under these conditions. As prime duration increases there should be a corresponding decrease in the amount of peripheral masking, if the masking parameters are kept constant. If Uttal's findings apply to the present context then a considerable increase in prime duration should be possible without a corresponding increase in Report. The longer prime duration may provide evidence for nonconscious associative priming. The following experiment investigates this possibility. Priming by three masked prime relations (solution, associated, unrelated) were tested across four prime durations (40, 60, 80 120 msec). Report was expected to increase with prime duration.

4.4.2. Method

(i) Subjects

Sixty (23 male, 37 female) first year psychology undergraduates participated as part of course requirements. Age range was 17 to 45 with a mean age of 22.5. Only subjects tested to have 6/6 vision were accepted for the experiment.

(ii) Apparatus

Materials, stimuli and apparatus were the same as in Experiment 11. The second mask was constructed in the same way as the first version. The forward mask was always different from the backward mask.

(iv) Procedure

Subjects were nonsystematically allocated to Duration (40 msec, 60 msec, 80 msec, 120 msec) and List (A, B, C). The procedure described for Experiment 11 was followed for each duration in the present experiment.

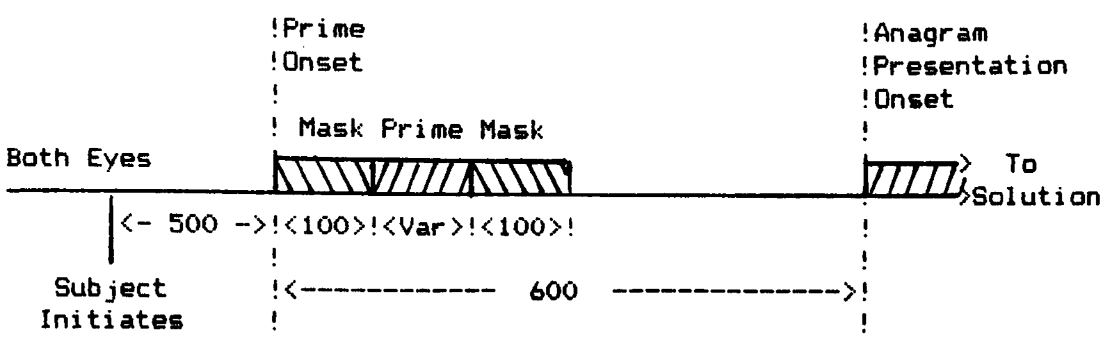


Figure 9

Presentation sequence for Experiment 12 (time in msec)

Two arrows were displayed in the middle of the screen during the resting phase. Subjects initiated each trial by pressing "Start". A 500 msec pause was followed by (a) the first mask displayed for 100 msec, (b) the prime displayed for 20 msec and (c) the second mask displayed for 100 msec. The SOA between prime and target remained constant at 600 msec.

4.4.3. Results

Post-experimental allocation to Report and No Report adopted the criteria used in Experiment 7 and fully described there. There were 35 Report and 25 No Report subjects, distributed nonuniformly across duration (see Figure 10). Mean solution times, mean number solved, Misses and Exclusions, for each duration are given in Table 16. The statistical analysis follows the same procedure as in Experiments 10 and 11.

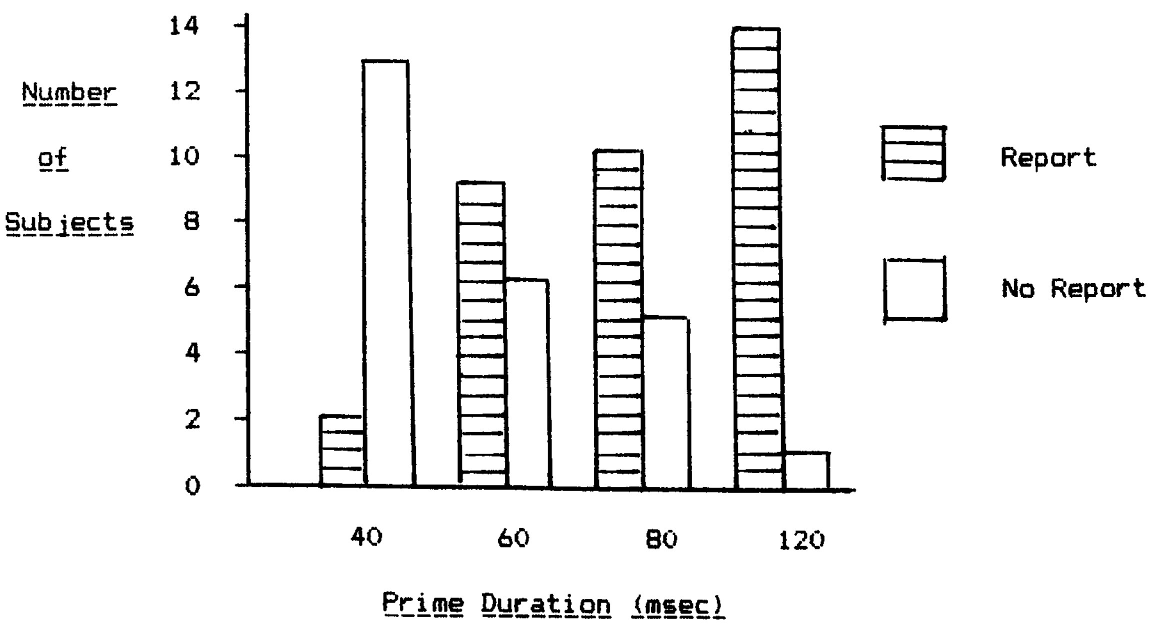


Figure 10

Distribution of Report across prime durations in Experiment 12

(a) Number of anagrams solved

A four-way ANOVA was performed with across subjects factors Report (Report, No report) and Duration (40, 60, 80, 120), and within subjects factors Prime Type (solution, associated, unrelated) and Cut-off (60 secs, 3 secs). (i) The effect of Duration is not significant, (ii) Report is significant (F (1,52) = 7.55, $p < .01$), (iii) the effect of Prime Type is significant (F (2,104) = 18.29, $p < .0001$), (iv) Cut-off is significant (F (1,52) = 133.96, $p < .0001$). The interaction between (i) Duration and

Table 16

Effect of Prime Type, Duration, and Report on solution time and number of anagrams solved in Experiment 12

	Priming Condition					
	Solution		Associated		Unrelated	
	Rep	NoRep	Rep	NoRep	Rep	NoRep
40 msec prime duration						
Number of subjects	2	13				
Mean solution time (secs)	2.6	6.9	4.0	7.0	5.5	6.3
Mean number Solved (Max=13)	11.5	11.2	12.0	10.3	12.0	10.5
Misses (% Condition)	0	7.1	0	9.5	0	12.4
Exclusions (% Condition)	11.0	7.1	7.8	10.7	0	5.9
60 msec prime duration						
Number of subjects	9	6				
Mean solution time (secs)	2.6	4.1	4.2	6.6	5.4	5.9
Mean number Solved (Max=13)	12.0	12.0	10.8	10.8	11.7	11.7
Misses (% Condition)	2.6	6.4	6.8	5.1	7.7	10.3
Exclusions (% Condition)	6.2	6.2	10.8	10.8	3.1	3.1
80 msec prime duration						
Number of subjects	10	5				
Mean solution time (secs)	1.7	3.3	4.4	4.7	5.2	5.9
Mean number Solved (Max=13)	12.3	11.8	11.6	9.8	11.6	11.0
Misses (% Condition)	1.5	7.7	3.8	10.8	5.4	9.2
Exclusions (% Condition)	3.8	1.5	6.2	5.9	6.2	6.2
120 msec prime duration						
Number of subjects	14	1				
Mean solution time (secs)	1.8	1.7	4.0	3.7	6.2	7.1
Mean number Solved (Max=13)	12.8	10.0	12.0	12.0	10.5	8.0
Misses (% Condition)	0	7.5	4.4	7.7	9.3	7.7
Exclusions (% Condition)	2.1	7.7	3.9	0	8.3	15
Across all durations						
Number of subjects	35	25				
Mean solution time (secs)	2.2	4.0	4.2	5.5	5.6	6.3
Mean number Solved (Max=13)	12.2	11.1	11.6	11.0	11.5	11.0

Prime Type is significant (F (6,104) = 3.8, $p < .01$), (ii) Prime Type and Cut-off is significant (F (2,104 = 14.14, $p < .0001$), (iii) Duration, Prime Type and Cut-off is significant (F (6,104) = 2.19, $p < .05$).

Separate analyses were performed to look at the effect of Report and Prime Type on the number solved at the two Cut-off points (60 seconds and three seconds).

<u>(i) Number of anagrams solved within sixty seconds</u>

A two way ANOVA with across subjects factor Report (Report, No Report) and within subjects factor Prime Type (solution, associated, unrelated) shows that (a) the effect of Report is significant (F (1,58) = 3.03, $p < .001$), (b) the main effect of Prime Type is significant (F (2,116) = 7.95, $p < .001$).

Separate one way within subjects ANOVA's with factor Prime Type were performed at each duration for both Report and No Report subjects:

<u>(a) Report</u>: The effect of Prime Type on the number of anagrams solved is significant at 120 msec prime duration (F (2,24) = 24.71, $p < .0001$), but is not significant at 40, 60, and 80 msec prime durations.

<u>(b) No Report</u>: The effect of Prime Type on the number of anagrams solved is not significant at any of the prime durations.

<u>(ii) Number of anagrams solved within three seconds</u>

A two way ANOVA with across subjects factor Report (Report, No Report) and within subjects factor Prime Type (solution, associated, unrelated) shows that (a) the effect of Report is significant (F (1,58) = 16.01, $p < .001$), (b) the main effect of Prime Type is significant (F (2,116) = 43.06, $p < .0001$), (c) there is a significant interaction (F (2,116) = 13.61, $p < .0001$). Separate one way within subjects ANOVA's on the effect of Prime Type were performed at each duration for both Report and No Report subjects:

<u>(a) Report</u>: The effect of Prime Type on the number of anagrams solved is significant at the following prime durations; (i) 60 msec (F (2,16) = 7.43,

$p < .01$), (ii) 80 msec (F (2,20) = 24.98, $p < .0001$), (iii) 120 msec (F (2,24) = 46.36, $p < .0001$).

(b) No Report: The effect of Prime Type on the number of anagrams solved is significant at 80 msec prime duration (F (2,8) = 4.97, $p < .05$), but not significant at 40, 60, and 120 msec durations. Further analyses at 80 msec prime duration indicates that the difference in number solved between solution and unrelated primed anagrams is marginal (F (1,4) = 7.56, p = .051). There were no other significant differences.

(b) Mean Solution Times

An overall three way ANOVA with across subject factors Report (Report, No report) and Duration (40, 60, 80, 120), and within subjects factor Prime Type shows (i) a marginal effect of Report (F (1,52) = 3.17, p = .058), and (ii) a significant effect of Prime Type (F (2,104) = 17.41, $p < .0001$), but (iii) Duration did not affect solution times.

Figures 11 and 12 appear to show an interaction between Prime Type, Duration, and Report. This interaction is not significant, possibly because there were so few subjects in some conditions. Figure 12 indicates that for No Report subjects there is substantial priming at long durations but clearly not at short durations. Figure 11 indicates that for Report subjects, priming effects are not significantly affected by Duration.

Separate one way ANOVA's with across subject factor Report (# 2) and within subjects factor Prime Type (# 3) were performed at each Duration.

40 msec duration: Neither the effect of Report nor of Prime Type is significant.

60 msec duration: The effect of Prime Type is significant (F (2,26) = 7.28, $p < .001$), but the effect of Report is not. Further analysis indicates that for Report subjects there is a significant difference in solution times between solution and unrelated primed anagrams (F (1,8) = 24.3, $p < .01$), but not between associated and unrelated primed anagrams. There were no significant differences for No Report subjects.

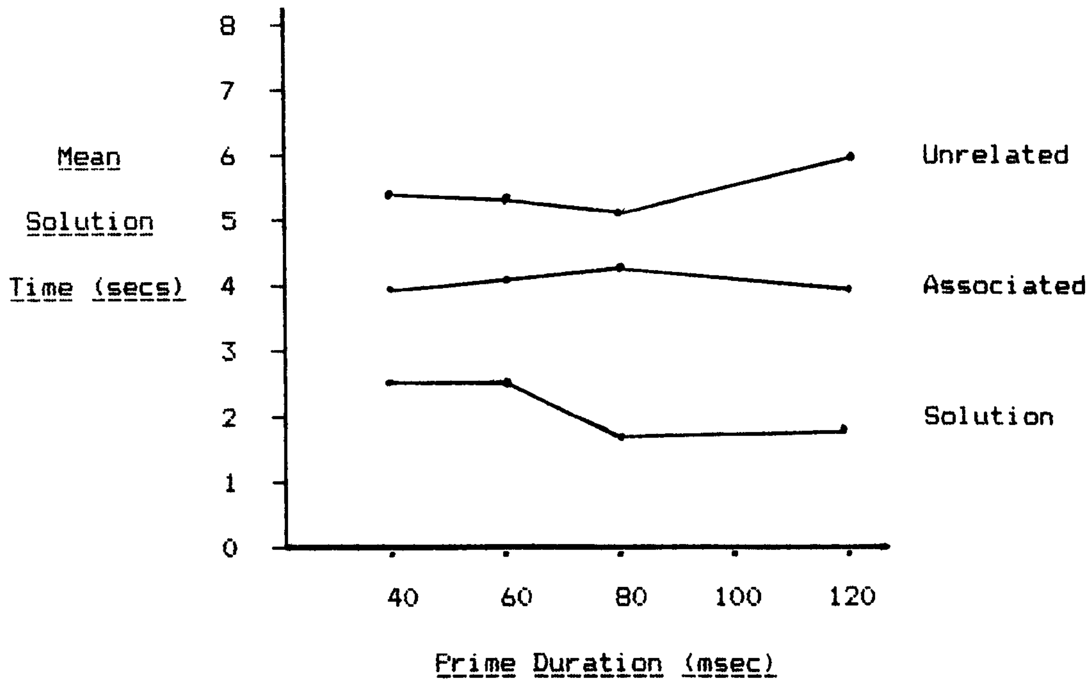


Figure 11
Effect of Prime Type and Duration on solution time for Report subjects in Experiment 12

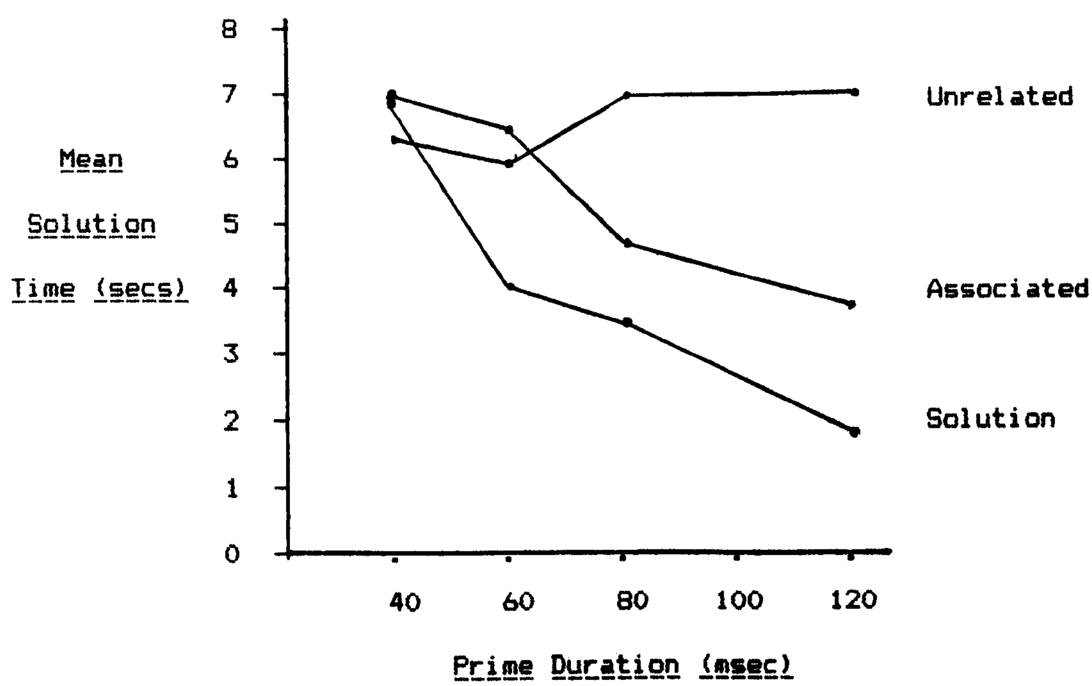


Figure 12
Effect of Prime Type and Duration on solution time for No Report subjects in Experiment 12

80 msec duration: The effect of Prime Type is significant (F (2,26) = 11.18, p < .001), but the effect of Report is not. Further analysis indicates that for Report subjects there is a significant difference in solution times between solution and unrelated primed anagrams (F (1,9) = 13.6, p < .01), but not between associated and unrelated primed anagrams. For No Report subjects the difference between solution and unrelated primed anagrams is also significant (F (1,4) = 15.04, p < .05), but the difference between associated and unrelated primed anagrams is not.

120 msec duration: The effect of Prime Type is significant (F (2,26) = 8.10, p < .01), but the effect of Report is not. Further analysis indicates that for Report subjects there is a significant difference in solution times between (i) solution and unrelated primed anagrams (F (1,13) = 91.6, p < .0001), (ii) associated and unrelated primed anagrams (F (1,13) = 6.93, p < .05), and (iii) solution and associated primed anagrams (F (1,13) = 16.73, p < .01). A within subject comparison for the one No Report subject revealed no significant differences.

Only five subjects were included in the No Report category at 80 msec Duration and one at 120 msec duration. Separate analyses performed for these six subjects indicate that the difference in solution time between (i) solution and unrelated primed anagrams is significant (t (5) = 4.79, p < .01), (ii) associated and unrelated primed anagrams is significant (t (5) = 2.59, p < .05, one tailed)), demonstrating a binocular nonconscious associative priming effect.

4.4.4. Discussion

(a) Criteria for awareness

The post-experimental Report allocation procedure was the same as in Experiment 11 and has already been discussed there. In the present experiment, the inverse relationship between prime duration and number of No Report subjects is as predicted (see Figure 10). The one subject who did not report seeing a prime word at 120 msec was questioned intensively subsequent to the normal questioning procedure at the end of the experiment to ascertain the veracity of her lack of report. Whatever way the questions were put she remained adamant that she did not see a prime word at any time.

Some subjects were able to identify the first prime word that they saw. These identifications were usually of primes which occurred in the last block of experimental trials. The identifications contained more solution and associated primes than unrelated primes. It is possible that all prime types were recognised equally often but subjects were better able to recall related primes. However, subjects often gave an indication of when they first saw a prime word by an exclamation of surprise or a sudden intake of breath. These incidents, recorded by the experimenter, supported the subject's post-experimental recall.

(b) Priming effects

The results demonstrate that it is possible to achieve effective masking under a wide range of prime durations. As expected the proportion of cases where masking is effective is inversely related to prime duration. Sandwiching the prime word between successive pattern masks allows an increase in prime presentation duration sufficient for nonconscious associated priming.

The duration of the prime appears to make little difference to amount of priming when subjects are aware of at least some aspect of a prime word. Figure 11 illustrates the separation between the solution, associated, and unrelated priming conditions for these Report subjects. A relatively constant amount of significant priming was obtained for both solution and associated primes, displayed from between 40 and 120 msec.

If the prime is not reported then priming effects seem to be dependent on how long the prime is displayed for. Figure 12 appears to show a regular psychometric function where the effect of Prime Type increases with duration. If the prime word is displayed for only 40 msec it does not appear to contribute at all to priming. Nonetheless, there were more anagrams solved within the first three seconds when preceded by the solution to the anagram, than when preceded by either of the other two Prime Types. A 60 msec prime duration provided sufficient nonconscious processing to enable solution priming. There was a similar significant increase in the number of anagrams solved at both three and sixty seconds. It was not until prime duration was 80 msec that the effect of associative priming became evident for the five No Report subjects at that duration. A similar result was obtained for the one subject who did not report seeing a prime or any part of it at 120 msec. Indeed, her solution times for solution and associative priming are as fast as those subjects who did report seeing a prime. If her results are added to those of five subjects who gave No Report at 80 msec, then for those six subjects, anagrams preceded by an associated word were solved significantly faster than those preceded by an unrelated word. This nonconscious associative priming effect is not as clear as might be hoped because there are so few No Report subjects.

Comparison between Figures 11 and 12 suggests different functions dependent on whether or not people are aware of the prime word. The graphs appear to provide support for the functional distinction based on Report which has been used throughout the present experiments. Brief presentations of stimuli which are detected can produce comparable priming effects to those obtained from much longer displays of the same stimuli where presentation is not detected. Awareness appears to reduce the dependence of priming on stimulus conditions. In other words, one function of conscious attentional processes may be to enhance activation in some way in order to overcome poor definition or "weak" stimuli.

Although nonconscious associative priming has been obtained, it is difficult to predict how robust this effect is. There are several reasons for this; (i) the marginal significance of the nonconscious associative priming effects, (ii) subjects were not told that a prime might be present, (iii) awareness was not determined until the end of the experiment.

It is possible that the small "nonconscious" associative priming effects may be attributed to occasions when subjects were aware of the prime but subsequently forgot the event. On the one hand, it would be a memorable event if the subject saw either a solution or an associated prime and linked this event with the solution to the anagram. On the other hand, the effort involved in trying to solve the 39 experimental anagrams may lead to the subject forgetting such an incident, particularly if it occurred early in the experiment. This argument would only be adequate to explain failure of post-experimental recall if there were only one or two occasions when the subject saw a prime word. It seems very unlikely that the subject would forget a large number of such events.

4.5. Experiment 13: Priming of anagram solving under varying masking conditions where awareness is determined by post-trial subject report

4.5.1. Introduction

In Experiment 12, subjects were not expecting to see a prime word. Several No Report subjects were unconvinced at the end of the experiment that a prime word had been presented. They were only assured of the fact after the experimenter showed them a slowed rerun of the condition in question. Some subjects were able to accurately identify the prime words. It is possible that a number of subjects had partial or complete knowledge of some primes but failed for some reason to report this. The following experiment poses two questions. First, what proportion of the critical No Report results might have been attributable to instances where subjects were aware of the prime but did not report? Second, would a similar result be obtained if subjects attentional strategy was influenced by their expectations? For example, if subjects are told that "something" will be presented, at least on some occasions, they will probably look for it instead of passively watching the same display and waiting for the anagram to appear. This should increase the proportion of Report data.

The results of the previous experiment demonstrated nonconscious associative priming for the combined 80 and 120 msec duration No Report subjects. Only one subject gave No Report at 120 msec. Preliminary testing showed that under the following procedure most subjects would be able to see prime words presented for 100 or 120 msec. Consequently only 60 and 80 msec prime durations are tested under forward and backward masking conditions. A third condition is included where the prime is presented for 20 msec but backward masked only as in Experiment 11. The issue of particular interest in the following experiment, is whether there will be any evidence for nonconscious priming when awareness is assessed on a trial by trial basis.

4.5.2. Method

(i) Subjects

Nine male and nine female first year psychology undergraduates participated as part of a course requirement. Age range was 17 to 23 with a mean of 19.6. Only subjects tested to have 6/6 vision were accepted for the experiment.

(ii) Apparatus

Apparatus and materials were the same as in Experiment 12, with one exception. Three stimuli were deleted from the stimulus set in order to provide a balanced set of primes and anagrams for the three prime Durations and three Prime Types. Thus 36 prime anagram pairs were used; there were four trials at each Duration and for each Prime Type.

(iv) Procedure

Each subject was randomly assigned to a List (A, B, C) and received all Prime Types (solution, associated, unrelated) at each Duration (20, 60, 80). Across subjects all targets were presented under each condition and all primes were presented at each duration. Procedure was the same as in

Experiment 12 with the following additions to instructions. Subjects were told that after they pressed "Start" they would see a string of symbols between the arrows in the centre of the screen, and on some occasions something other than the symbols would appear. Their tasks were (a) to solve the anagram as quickly as possible, (b) speak their answer into the microphone, and (c) to report whether or not they had seen anything other than the symbols before the anagram appeared. Full instructions are given in Appendix A.12.

(v) Presentation sequence

For the 60 and 80 msec durations the presentation sequence was the same as in Experiment 12. For the 20 msec duration the sequence was the same as in Experiment 11. In addition, at the end of each trial there was a one second dark period followed by a two second display of the message "That was trial £ (X) : Was there anything other than the symbols?". The display then returned to the resting state (arrows only) until the subject pressed "Start" for the next trial.

4.5.3. Results

At each of the prime Durations there were only four presentations of each Prime Type. Trials were allocated to Report category adopting the same criteria as in Experiment 8. This produced 56% Report trials and 44% No Report trials. All subjects provided some Report and some No Report trials. However many subjects failed to provide Report or No Report results for some Prime Types or Durations. Misses and Exclusions were assessed as in Experiment 10. Mean solution times are calculated from the trials data. Mean solution times and number of trials for both Report and No Report at each Duration, are given in Table 17. Misses and Exclusions are given for Report and No Report trials overall.

Table 17

<u>The effect of prime duration on Report and solution time in Experiment 13</u>

	Priming Condition		
	Solution	Associated	Unrelated
<u>REPORT TRIALS</u>			
<u>(a) 20 msec prime duration</u>			
Mean solution time (secs)	2.6	2.8	7.8
Number of trials	24	20	14
<u>(b) 60 msec prime duration</u>			
Mean solution time (secs)	1.5	3.0	5.6
Number of trials	46	44	37
<u>(c) 80 msec prime duration</u>			
Mean solution time (secs)	1.4	3.2	5.6
Number of trials	57	51	41
<u>(d) Overall results</u>			
Mean solution time (secs)	1.6	3.2	5.6
Misses (% total trials)	0.7	2.4	6.6
Exclusions	3.7	2.3	3.7
<u>NO REPORT TRIALS</u>			
<u>(a) 20 msec prime duration</u>			
Mean solution time (secs)	2.9	4.8	5.8
Number of trials	38	41	44
<u>(b) 60 msec prime duration</u>			
Mean solution time (secs)	3.9	5.5	7.1
Number of trials	18	20	24
<u>(c) 80 msec prime duration</u>			
Mean solution time (secs)	3.3	5.4	6.6
Number of trials	10	13	20
<u>(d) Overall results</u>			
Mean solution time (secs)	3.1	5.5	6.3
Misses (% total trials)	7.8	10.8	11.8
Exclusions	3.2	4.6	2.8

(a) Number of anagrams solved

(i) Within 60 seconds: A three way within subjects ANOVA was performed with factors Report (Report, No report), Duration (20, 60, 80), and Prime Type (solution, associated, unrelated). The effect of (i) Report is not significant but is suggestive (F (1,17) = 3.27, p = .08), (ii) neither the effect of Duration nor Prime Type has a significant effect on the number of anagrams solved. The interaction between (i) Duration and Report is significant (F (2,34) = 30.91, $p < .0001$), (ii) Prime Type and Report is significant (F (2,34) = 5.13, $p < .05$). Separate analysis of the number of anagrams solved by Report and No Report trials showed:

Report trials: a one way ANOVA across all Durations shows that the effect of Prime Type is significant (F (2,34) = 6.53, $p < .01$). The difference in number solved between (i) solution and unrelated primed anagrams is significant (F (1,17) = 11.24, $p < .01$), (ii) associated and unrelated primed anagrams is significant (F (1,17) = 5.02, $p < .05$).

No Report trials: a one way ANOVA across all Durations shows that the effect of Prime Type is significant (F (2,34) = 3.41, $p < .05$). This effect is attributable mainly to the difference between solution and unrelated primed anagrams (F (1,17) = 5.46, $p < .05$). Associative priming was not significant.

(ii) Number solved within three seconds: The following analysis is for number solved for Report and No Report trials. This was collapsed across Duration as there was insuffucient data to include Duration as a factor. A two way within subjects ANOVA with factors Report (# 2) and Prime Type (# 3) shows that the following effects are significant (i) Report (F (1,17) = 12.78, $p < .01$), (b) Prime Type (F (2,34) = 27.4, $p < .0001$), and (c) the interaction (F (2,34) = 9.94, $p < .001$). Further analyses were of Report and No Report separately.

Report trials: the difference in number solved between (i) solution and unrelated primed anagrams is significant (F (1,17) = 34.99, $p < .0001$), (ii) associated and unrelated primed anagrams is significant (F (1,17) = 19.6, p < .001).

No Report trials: there are no significant differences.

(b) Mean Solution Times

Several subjects failed to provide Report or No Report data for each Duration and Prime Type. Duration was collapsed within subjects to allow an analysis of variance on the overall results. Two subjects failed to provide an overall No Report mean, and one subject failed to provide an overall Report mean for one Prime Type. An analysis of variance was perfomed on the data provided by the remaining 15 subjects. A two way within subjects ANOVA on the overall results with factors Report (Report, No report) and Prime Type (solution, associated, unrelated) shows (i) the effect of Report is significant (F (1,14) = 7.47, p < .05), and (ii) the effect of Prime Type is significant (F (2,28) = 10.82, p < .001). Separate analyses of the significant Prime Type effect for No Report trials revealed significant differences between (i) solution and unrelated primed anagrams (F (1,14) = 6.3, p < .05), and (ii) between solution and associated primed anagrams (F (1,14) = 5.82, p < .05). Associative priming was not significant. There was a further analysis of Report and No Report trials at each Duration.

Report trials

20 msec duration: the only significant difference is between solution and unrelated primed anagrams (t (18) = 1.8, p < .05 (1 tailed)).

60 msec duration: the difference in solution time between (i) solution and unrelated primed anagrams is significant (t (31) = 2.68, p < .01), and (ii) solution and associated primed anagrams is significant (t (31) = 2.18, p < .05).

80 msec duration: the difference in solution time between (i) solution and unrelated primed anagrams is significant (t (32) = 4.96, p < .001), (ii) solution and associated primed anagrams is significant (t (32) = 2.16, p <

.05), and (iii) associated and unrelated primed anagrams is significant (*t* (34) = 2.12, *p* < .05).

No Report trials

20 msec duration: the only significant difference is between solution and unrelated primed anagrams (*t* (29) = 2.21, *p* < .05).

60 msec duration: the difference between solution and unrelated primed anagrams is significant (*t* (23) = 1.46, *p* < .05 (1 tailed)).

80 msec duration: there are no significant differences between priming conditions.

4.5.4. Discussion

(a) Criteria for awareness

Criteria for awareness are the same as those in Experiment 8, except that a different intervening task was employed. The Report distribution for the present 20 msec duration may be compared with the post-experimental report distribution in Experiment 11. In that experiment 5/15 subjects gave No Report. In Experiment 13, when subjects were asked to report at the end of each trial, 2/18 subjects gave No Report (20 msec duration only). Seven other subjects who provided Report data at 20 msec duration did so for only one trial. None of these subjects were able to identify the prime. Altogether, half of the subjects could report either little or no awareness of the primes. As both time of report and instructions to subjects differed between experiments, it is not possible to determine which variable most affected the difference in Report distribution. Whatever the reason, the trial by trial procedure should provide a more accurate estimate of report because (i) it can more easily accommodate changes in sensory sensitivity, (ii) changes in response criteria, (iii) changes in attentional strategy, and (iv) allows the subject to provide a more immediate account of what they were aware of.

(b) Priming effects

The most important result from this experiment is that the nonconscious solution priming effect remains significant at both 20 and 60 msec prime durations, when awareness is determined post-trial. The nonconscious associative priming effect in Experiment 13 remains at the same absolute level as in Experiment 12 and, although large and regular, is nonsignificant. The assumption is that report accuracy is greater in the post-trial procedure, compared to the post-experimental procedure. If part of the "nonconscious" priming effect obtained using a post-experimental criterion (Experiments 11 and 12) was due to conscious but unreported priming, then nonconscious priming should be lower as report accuracy increases. Comparison with the results of comparable presentation conditions in Experiments 11 and 12 shows that trial by trial determination of awareness produces equal or larger nonconscious priming effects than does post-experimental report.

It is still possible that subjects are failing to report solution primes for some reason or another, and even post-trial questioning is insufficient. Several subjects throughout the course of the experiments stated that sometimes they imagined the prime rather than saw it. They were only convinced that they had actually seen the word after this had happened a few times. Failure to report may be connected with recall inability subsequent to interference from the anagram solving task. In the following experiment subjects are asked, before they attempt to solve the anagram, whether or not a prime word was present.

4.6. Experiment 14: Priming of anagram solving in a two-task paradigm with prime report preceding anagram presentation.

4.6.1. Introduction.

The results of Experiment 13 show nonconscious solution priming in the absence of significant nonconscious associative priming. Nonconscious solution priming may be due to some contribution from conscious attentional processes. For example, partial cue information (such as the first letter of the solution) may be consciously available at the time of presentation. If this information is only weakly represented then interference from the anagram solving task may interact with recall. The following experiment investigates nonconscious priming where prime recall is not subject to interference from the anagram solving task. A two-task trial by trial procedure is used, where a presence-absence judgement precedes presentation of the anagram. This procedure is included within the most restricted version of Dixon's (1971) second criterion for assessing awareness. The intention was to keep the following experiment as comparable as possible with Experiments 11 and 12. However, the the manual presence-absence task required an increase in prime-anagram SOA of 160 msec to 760 msec SOA.

4.6.2. Method

(i) Subjects

Five female and ten male first year psychology undergraduates took part as a course requirement. Age range was 18 to 39 with a mean of 24.5. All subjects were tested to have 6/6 vision.

(ii) Apparatus

The same apparatus was used as in Experiment 11, but with the following additions. A response panel was constructed similar to the one described in the LDT experiments (see Experiment 6). Three low profile fast reponse buttons, similar in operation to touch sensitive membranes, were used to allow maximum facilitation in RT. They were situated 3.3 in. apart in an inverted triangle, marked "YES" and "NO" at the top and "StART" at the bottom. The response buttons were connected to the interrupt timer in the microcomputer. All other equipment, materials and stimuli were the same as in Experiment 11.

(iii) Procedure

Initial procedure was the same as in Experiment 13. Instructions were the same except that subjects were told that after pressing "Start" they would see a string of symbols appear between the arrows, and on some occasions they might see something other than the symbols. If they saw anything other than symbols they were to press the "YES" button (dominant hand) as quickly as possible. If they saw only symbols, they were to press the "NO" button (nondominant hand) as quickly as possible. If response was too slow then they would receive a message telling them it was "Too late" and asking them to try again. After the "Yes/No" decision they would be presented with an anagram. Their second task was to solve the anagram as quickly as possible and speak the answer into the microphone. Further instructions were the same as in Experiment 13 except that at the end of each trial subjects were asked to elaborate on what they had seen prior to the anagram.

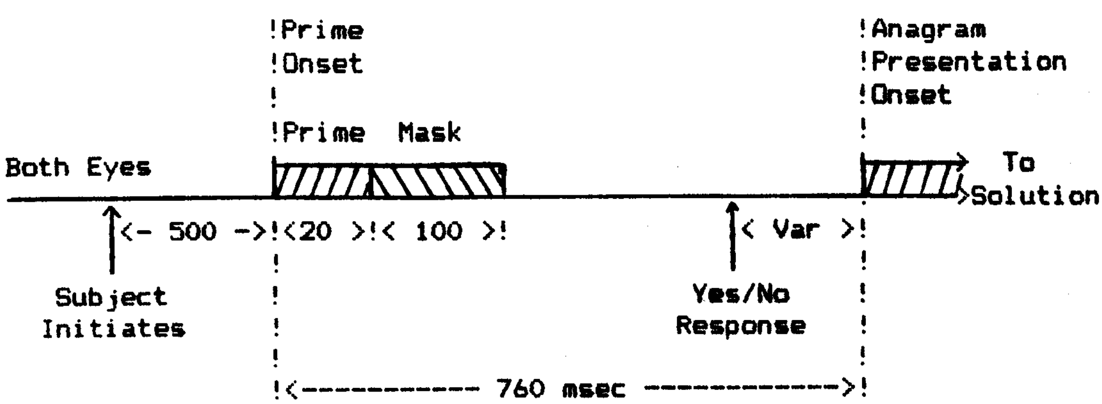


Figure 13
<u>Presentation sequence for Experiment 14</u> (time in msec)

(iv) Presentation Sequence

During the resting phase two arrows were displayed 1.2 in. apart in the centre of the screen. Subjects initiated each trial by pressing "START". This was followed by a sequence of (a) a 500 msec pause (b) a 20 msec display of the prime, (c) a 100 msec presentation of the mask, (d) a dark period followed to produce a prime-anagram SOA of 760 msec. If a "Yes/No" response was not made within 760 msec, then the message "Too late : Try again?" was dispayed in the centre of the screen. Missed trials were re-presented at the end of the experimental trials. The anagram was displayed until subject verbal response or 60 seconds. Finally, the message "Was there anything other than symbols? Please reply into the microphone" was displayed for two seconds. The subject's reply was recorded by the experimenter.

4.6.3. Results

"Yes" responses were classed as Report and "No" responses as No Report. This produced 72% No Report trials and 28% Report trials. Six subjects provided only No Report data on all trials; 14 subjects provided No Report data on some trials; and nine subjects provided Report data for some trials. Mean solution times, number of trials, Misses and Exclusions for Report and No Report trials are displayed in Table 18.

(a) Analysis of Number of anagrams solved

The data provided by the nine subjects who provided both Report and No Report data, used in the following analyses, is presented in Table 18.
(i) Number solved within 60 seconds: A two way within subject ANOVA with factors Report (Report, No Report) and Prime Type (solution, associated, unrelated) shows no significant effects.
(ii) Number solved within 3 seconds: A two way within subject ANOVA with factors Report (Report, No Report) and Prime Type (solution, associated, unrelated) indicates that the effect of Prime Type is significant (*F* (2,16)

= 6.61, $p < .01$). Further analysis was of Report and No Report separately. There are no significant differences for Report. For No Report subjects the only significant difference is between the number of solution and unrelated primed anagrams solved ($F_{(1,8)} = 5.42$, $p < .05$).

Table 18

The effect of Priming and Report on solution times in Experiment 14

	Priming Condition		
	Solution	Associated	Unrelated
REPORT TRIALS			
Mean Solution Time (secs)	4.4	6.3	7.4
Number of trials	54	46	53
Misses (% Condition)	0	0	3.5
Exclusions (% Condition)	1.1	0.9	1.1
NO REPORT TRIALS			
Mean Solution Time (secs)	4.2	5.3	5.5
Number of trials	123	121	111
Misses (% Condition)	7.5	10.9	10.1
Exclusions (% Condition)	1.4	1.2	1.4

(b) Analysis of Mean Solution Times.

The data provided by the nine subjects who provided both Report and No Report data was analysed in a two way within subjects ANOVA with factors Report (Report, No Report) and Prime Type (solution, associated, unrelated). The effect of Prime Type is significant ($F_{(2,16)} = 4.81$, $p < .05$). Further analysis was of Report and No Report separately.

(i) Report: there are no significant differences.

(ii) No Report: For No Report subjects the difference between solution and unrelated primed anagrams is not significant but is suggestive (F (1,8) = 4.53, p = .06). The means for the five subjects who provided No Report data only was added to the analysis. A one way within subjects ANOVA for the 14 No Report means shows that the effect of Prime Type is significant (F (2,26) = 3.42, $p < .05$). Separate analyses reveal that the difference in solution time between (a) solution and unrelated primed anagrams is significant (t (13) = 2.32, $p < .05$), (b) solution and associated primed anagrams is significant (t (13) = 3.63, $p < .05$).

In a further analysis the results for the five No Report only subjects were compared with the overall means for those subjects who provided both Report and No Report. A two way ANOVA with across subjects factor Report and within subjects factor Prime Type shows that only the effect of Prime Type is significant (F (2,26) = 4.94, $p < .05$).

4.6.4. Discussion

(a) Criteria for awareness

The introduction of a speeded manual Yes/No response raises two problems (i) the relationship between manual and verbal responses to the same display conditions, (ii) the relationship between post-mask and post-trial presence-absence decisions.

For the first of these, possibly the most important factor influencing the relationship is that the manual Yes/No decision was speeded. Subjects had to make a decision within 760 msec in order to complete the trial. Response criteria are likely to be different under these conditions compared with when subjects are allowed ample time to make the same decision. There is no way to determine whether this speeded decision resulted in a higher number of errors, or if there was a systematic bias in these errors. The "Yes" response was always to the subjects dominant hand. It was expected that any systematic effects would be reflected in a positive ("Yes") response bias. However, there was a higher proportion of "No" responses in this experiment than No Report under post trial report procedures (Experiments 8 and 13). The intention was to reduce the likelihood that No Report data was contaminated by consciously processed but unreported primes, while keeping other experimental parameters as constant as possible. It was hoped that the present procedure would provide an estimate of what proportion of primes subjects would have been able to detect in Experiments 11, 12, and 13 if they had concentrated their efforts on doing so.

The second problem was the relationship between the manual post-mask and verbal post-trial decisions of awareness. In post-trial decisions, subjects may be unable to recall accurately whether or not they saw anything of the prime because of the interference of the anagram solving task. This decision may require recall from LTM. A speeded decision post-mask may be made on the basis of the contents of STM. In Experiment 13 report, even of a vague "something", was included as Report. In Experiment 14, subjects were asked to respond "Yes" if they saw "something" other than symbols. Given this, "Yes" responses are taken as equivalent to Report and "No" responses as equivalent to No Report.

(b) Priming effects

Nonconscious solution priming provided significantly faster solution times compared with unrelated priming. A small but non significant nonconscious associative priming effect was obtained. Nonconscious solution priming is less in the present experiment than in Experiments 11 and 13 where presentation conditions were similar. In Experiment 11 nonconscious solution priming was 2.2 seconds; in Experiment 13 it was 2.9 seconds; but in the present experiment it is only 1.3 seconds. The greatest difference between the three experiments is in the time of Report. Report was post-experimental in Experiment 11, post-trial in Experiment 12, and post-prime in Experiment 13. Unrelated solution times are considerably lower in the present experiment compared with the other two and solution primed times are higher. It may be that effects attributable to nonconscious solution priming in previous experiments were due to conscious partial cues which some subjects failed to report. Whatever the reason, results demonstrate that nonconscious solution priming can be obtained under rigorous conditions for determining awareness. Nonconscious associative priming, although small and nonsignificant was again in the predicted direction. The following experiment adopts dichoptic presentation in an attempt to provide significant nonconscious associative priming in anagram solving.

4.7. Experiment 15: Priming of anagram solutions with dichoptic presentation, where awareness is determined by post-trial subject report.

4.7.1. Introduction

Nonconscious associative priming in the lexical decision task was significant under dichoptic presentation but not under binocular presentation (Chapter 3). Discussion of the LDT results concluded that binocular presentation produces a degree of peripheral masking due to integration between prime and mask. Intact aspects of the prime representation were sufficient to allow priming of a physically identical word, but insufficient to prime an associated word. Anagram solving produces large conscious associative priming effects, and significant evidence for nonconscious associative priming was expected. However the same problems have been encountered with the anagram solving task as with the LDT. The failure to achieve nonconscious associative priming under binocular presentation may be due to partial peripheral masking. The following experiment uses dichoptic presentation to ensure central masking (Turvey, 1973) in an attempt to obtain nonconscious associative priming of anagram solutions.

4.7.2. Method

(i) Subjects

Six female and six male volunteer undergraduates were paid £2 for participation in the experiment. Their ages ranged from 19 to 47 with a mean of 23. All subjects were tested to have 6/6 vision.

(ii) Apparatus: was the same as in Experiment 9. The masks and prime-anagram lists were the same as in Experiment 11.

(iii) Procedure

Subjects were tested for acuity using a Lizar's eyesight testcard, and for dominance using the aligning technique described in Chapter 2. Subjects were seated at the stereoscope. Instructions were as in Experiment 11, except that subjects were told that stimulus presentation would be to each eye independently. Two squares were displayed on the screen (appearing as one square to the subject), and subjects were asked if they saw a clearly defined square. No convergence adjustments were found necessary for any of the subjects. One block of 18 practice trials was followed by two blocks of experimental trials (20 and 19 trials respectively). There was a two minute pause between each block. At the beginning of each block the squares were redisplayed to check that convergence remained stable. At the end of each trial knowledge of results was provided, as in Experiment 6, but abbreviated to allow for dichoptic presentation. Two additional trials provided a post experimental check to ensure that each subjects could have seen the prime word clearly if it had not been masked. In this procedure a filter was inserted into the stereoscope to block stimuli presented to the dominant eye. Subjects were asked to name the (prime) word. All subjects were able to perform this task on the first trial.

(iv) Presentation Sequence (see Figure 14)

During the resting phase two arrows were displayed in the centre of either side of the "split" screen and remained on throughout the experiment. Subjects initiated each trial by pressing "Start". This was followed by a sequence of (a) a 500 msec pause, (b) a 20 msec display of the prime to the nondominant eye, (c) a 100 msec display of the mask to the dominant eye, (d) a 480 msec dark period, (e) simultaneous presentation of the anagram to both eyes. Subject vocal response, or an elapsed time of 60 seconds, terminated the trial. The solution and solution time were then presented. Finally, a display reminded the subjects to report whether something other than the symbols had been presented.

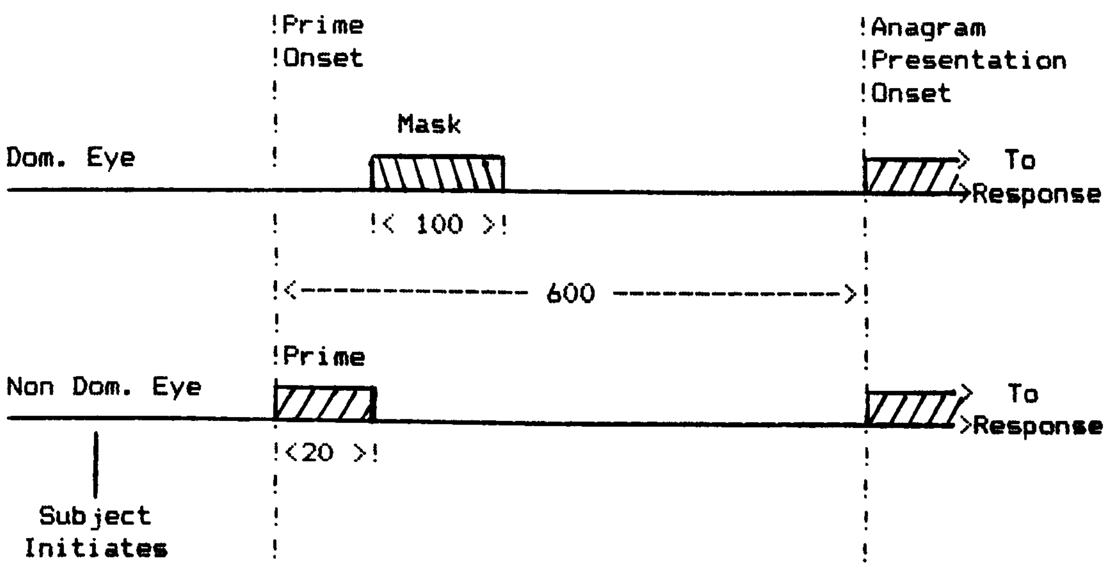


Figure 14

Presentation sequence for Experiment 15 (time in msec)

4.7.4. Results

Trials were categorised as Report or No Report trials using the criteria adopted throughout the previous experiments. This produced 87% No Report trials and 13% Report trials. Seven subjects did not report seeing a prime or any part of it during the experiment. The other five subjects provided both Report and No Report trials.

Table 19

The effect of dichoptic pattern masking on Report and solution time in Experiment 15

	Priming Condition		
	Solution	Associated	Unrelated
REPORT TRIALS			
Mean Solution Time (secs)	1.7	2.7	5.1
Number of trials	28	16	18
Misses (% Condition)	3.4	0	0
Exclusions (% Condition)	0.7	0.7	0
NO REPORT TRIALS			
Mean Solution Time (secs)	2.9	4.8	6.5
Number of trials	113	118	118
Misses (% Condition)	8.6	8.0	8.0
Exclusions (% Condition)	2.6	5.1	5.1

Mean solution times, number of anagrams solved, Misses, and Exclusions, for Report and No Report trials across all subjects are presented in Table 19. The data is for Report and No Report trials across all subjects. There were fewer Misses for Report than No Report. Misses did not differ across Prime Type for No Report. There were no Exclusions for Report trials and fewer Exclusions for solution than for unrelated primes for No Report trials.

(a) Number of anagrams solved

The data for the five subjects who provided both Report and No Report data is analysed first. A two way within subject ANOVA with factors Report (Report, No Report) and Prime Type (solution, associated, unrelated) shows no significant main effects on the number solved within either three second or 60 seconds. The interaction between Report and Prime Type is significant for number solved within 60 seconds (F (2,8) = 8.05, $p < .05$)and marginal for the number solved within three seconds (F (2,8) = 4.24, $p = .055$).

The No Report trials data was added to that of the seven No Report only subjects. A two way within subject ANOVA with factors Report (Report, No Report) and Prime Type (solution, associated, unrelated) was performed on the number solved within (i) 60 seconds and (ii) three seconds.

__(i) Number solved within 60 seconds:__ There are no significant differences.

__(ii) Number solved within three seconds:__ The effect of Prime Type is significant (F (2,22) = 4.21, $p < .05$). Further analysis indicates a significant difference in number of anagrams solved between (a) solution and unrelated primed anagrams (F (1,16) = 6.91, $p < .05$), and (b) associated and unrelated primed anagrams (F (1,16) = 5.76, $p < .05$).

__(b) Analysis of Mean Solution Times.__

The data provided by the five subjects who provided both Report and No Report data was analysed in a two way within subjects ANOVA with factors Report (Report, No Report) and Prime Type (solution, associated, unrelated). There are no significant differences. The means for the seven subjects who provided No Report data only was added to the analysis. A one way within subjects ANOVA for the 12 No Report trials means shows that Prime Type is significant (F (2,22) = 18.13, $p < .0001$). Separate analyses reveal that the difference in solution times between (a) solution and unrelated priming is significant (t (11) = 5.53, $p < .001$), (b) associated and unrelated priming is significant (t (11) = 2.58, $p < .05$), and (c) solution and associated primed anagrams is significant (t (11) = 4.2, $p < .01$).

In one further analysis the results for the seven No Report only subjects were compared with the overall means for those subjects who provided both Report and No Report. A two way ANOVA with across subjects factor Report and within subjects factor Prime Type shows that (a) Report solution times are significantly faster (F (1,10) = 7.44, $p < .05$), and (b) Prime Type is significant (F (2,20) = 15.72, $p < .001$).

4.7.4. Discussion

(a) Criteria for awareness.

The problem of interference from the anagram solving task on report accuracy in post- trial report procedure has been discussed with respect to Experiments 8, 9, 13 and 14. In this experiment 7/12 (58%) subjects gave entirely No Report trials. This compares favourably with the 10/15 (67%) subjects who gave only No Report data in the dichoptic LDT experiment (Experiment 9). A subject who assisted with preliminary testing for this experiment had also taken part in Experiment 13. She reported that the subjective evidence for report was different under the two modes of presentation. Under binocular presentation there was often an impression that "something" was there. Decisions were often difficult. Under dichoptic presentation the impression was more definite. The prime was either there or not there. There is no further information on qualitative differences in introspective evidence across mode of presentation as subjects were only allowed to take part in one of the present experiments.

(b) Priming effects

The suggestion that failure to achieve significant nonconscious associative priming under binocular presentation may have been due to a contribution from peripheral masking is supported by the results. Nonconscious solution priming is as robust as in previous experiments. Nonconscious associated priming is also clearly demonstrated. The nonconscious associative priming effect is supported by both differences in mean solution times and by the number of anagrams solved within the first three seconds. It appears that mode of presentation may be important in obtaining these significant results.

4.8. Discussion: Priming without Awareness in anagram solving

(a) Criteria for awareness

Dixon's (1971) second criterion was adopted in various forms to determine awareness in Experiments 11 to 15. A 20 msec display of the prime followed by a 100 msec display of a mask, with binocular presentation, produced the following pattern of results.

1. When awareness was determined by post-experimental report (Experiment 11) five of the 15 subjects gave No Report.

2. Awareness determined by post-trial report (Experiment 13) produced 68% No Report trials in the 20 msec prime duration condition. Two of the 18 subjects produced only No Report trials. Seven other subjects produced only one Report and none of these were able to identify a prime word.

3. Awareness determined prior to anagram presentation on the basis of a "Yes-No" response (Experiment 14), produced 72% No Report trials. Six of the 15 subjects gave only No Report trials.

The proportion of No Report data does not dramatically decrease as time of retrospective report approaches prime presentation. Two assumptions suggested that it would. First, post experimental retrospective reporting could produce false No Report data. False No Report would be due to subjects inability to recall caused by the intervening interference of the anagram solving task. Second, instructions were designed to increase the level of attention directed towards the prime as retrospective report approached prime presentation. It was assumed that attention to the appropriate position in space where the prime appeared would be active rather than passive, and a greater proportion of subjects would be attempting to detect the prime. No Report under these conditions was expected to be lower. Report accuracy should not be affected by anagram solving interference in the post-mask procedure. In addition, subjects were actively looking for the prime. The similarity between post-mask and post-experimental No Report distribution suggests that post-experimental No Report data was largely unaffected by recall deficiency.

When awareness was determined by post-trial report under dichoptic presentation (Experiment 15), 87% of the trials were No Report. Seven of the 15 subjects gave only No Report trials. Dichoptic presentation appears to provide more effective masking than binocular presentation under the same luminance and presentation conditions. This finding supports that of the LDT series (Chapter 3) but conflicts with the earlier pilot studies on the SOA technique. However it should be noted that (i) the subjects for this experiment were not drawn from the pool of introductory psychology students, (ii) there are wide individual differences in detection sensitivity which are reflected by the No Report distributions.

Table 20

Solution and associated anagram priming effects measured from the unrelated condition in Experiments 10 to 15.

Expt No	Time of Report	Masking	Durn (msec)	Priming Effects (secs) Solution Rep	Solution NoRep	Associated Rep	Associated NoRep
10	Not Masked		500	5.4		4.4	
11	Post-Exptl	Backward	20	3.5	2.2	1.0	0.8
12	Post-Exptl	Forward	40	2.9	-0.6	1.5	-0.7
12	" "	and	60	2.8	1.8	1.2	-0.6
12	" "	Backward	80	3.5	2.6	0.8	1.5
12	" "	"	120	4.4	5.4*	2.2	3.1*
13	Post-trial	Backward	20	5.2	2.9	5.0	1.0
13	" "	"	60	4.1	3.2	2.6	1.6
13	" "	"	80	4.2	3.3	2.4	1.2
14	Post-Mask	"	20	3.0	1.3	1.1	0.2
15	Post-trial	Dichoptic & Backward	20	3.4	3.6	2.4	1.7

* one subject only

(b) Priming effects (see Table 20)

Large conscious solution and associative priming effects have been demonstrated (Experiment 10). These results support Dominowski and Ekstrand's (1967) findings of both solution and associative priming effects, but not those of Jablonski and Mueller (1972), who found no associative priming effects.

The main results for the No Report data in Experiments 11 to 15 are as follows:

(i) Significant nonconscious solution priming is obtained under all of the criteria used to determine awareness.

(ii) Significant nonconscious associative priming was obtained only (a) under dichoptic presentation (Experiment 15), and (b) with long prime durations under binocular presentation (Experiment 12). However, nonconscious associative priming appears to be present under all of the criteria for determining awareness.

(iii) The amount of nonconscious solution priming increases with prime duration, becoming comparable to conscious solution priming at 120 msec (Experiment 12).

(iv) The amount of nonconscious associative priming varies nonsystematically with time of report. It does not become comparable to conscious associative priming at any prime duration.

(v) As priming increases with prime duration (Experiment 12), the large conscious priming effects obtained in Experiment 10 may be partly determined by the longer prime duration in that experiment.

(vi) Nonconscious priming effects are lower in Experiment 14 compared to Experiments 11 and 13. In Experiment 14, the first task in the two task procedure required close attention and was considered demanding by some subjects. The reduced priming effect may be partly attributable to interference from this intervening task.

The results overall indicate that nonconscious priming may extend to the level of the semantic system. The conditions which demonstrate this are restricted. The only evidence for semantic access under normal (binocular) viewing is when masking conditions permit a relatively long prime duration in the absence of awareness. Stronger evidence for associative priming without awareness is provided under dichoptic presentation conditions. The overall results are similar to those obtained in Experiments 6 to 10 investigating priming in the lexical decision task. They also provide support for Marcel's (1983b) claim for a dissociation between automatic information processing and conscious awareness. The results of Experiment 12 suggest that awareness of some aspect of a briefly presented prime word increase priming effects to a level where they are comparable with much longer displays of the prime presented without awareness. This indicates that one difference between automatic and conscious attentional processing may be that conscious attentional processes are able to enhance processing of brief or degraded stimuli, whereas automatic processes are more dependent on the stimulus characteristics.

The results support the suggestion that priming affects the second stage of anagram solving by increasing the availability of both the solution and its associates in the lexicon (Schuberth et al., 1979). This increased availability provides facilitation for memory search processes in the subsequent matching of the output of the first-stage letter recombination procedure. Although letter recombination appears to be primarily a conscious attentional process, it is possible that priming influences the way in which letters are recombined, thereby providing additional facilitation. There is no direct evidence for this notion, but there does seem to be a fast-acting "intuitive" process in anagram solving which appears to bypass the letter recombination stage. This intuitive mode of anagram solving could be produced by a feed forward priming effect which directly influences the way in which letters are recombined to form possible solutions.

CHAPTER FIVE

General Discussion

5.1. Criteria for Awareness

The criteria adopted to determine whether a person is or was unaware of a particular stimulus continues to be a major issue in attempts to study behaviour without awareness (Eriksen, 1960, 1962; Dixon, 1971; Spielberger, 1962; Mandler, 1975; Marcel, 1983a). Dixon (1971) suggests two categories of perception without awareness (a) "subliminal perception", where the stimulus is presented at or below a particular threshold, and (b) "unconscious perception", where responses are governed by stimuli of which the recipient is unaware. Both categories are employed in the preceding experiments and will be discussed separately.

5.1.1. Subliminal perception and the critical SOA procedure

Marcel's (1983a) critical SOA procedure establishes a detection threshold, which prevents stimulus identification to a predetermined criterion. A behavioural effect produced by stimuli under these conditions "seems to constitute an example of subliminal perception" (Marcel, 1983a, p.217). The underlying assumption in experiments using the critical SOA procedure to determine awareness appears to be that the threshold, once established, is fixed (Marcel, 1980, 1983a; Marcel and Patterson, 1978; Fowler et al., 1981). There are two serious weaknesses in this assumption. First, the evidence from SDT analysis (Swets, Tanner, and Birdsall, 1961; Swets, 1964) suggests that the notion of a fixed psychophysical threshold insufficiently describes performance. All signals contribute to a sensory continuum which varies and upon which probablistic decisions are based. The decision that a signal is either present or absent is determined by both sensory sensitivity and response criteria. Second, Stevens (1951) states that "ordinarily the threshold is not invariant with time. Rather it shifts about from moment to moment and we are forced to catch it on the fly". If thresholds can vary over time or trials (Stevens, 1951), or either sensory sensitivity or response criterion can change over time or trials (Swets, 1964), then it is possible that subjects can become aware of masked primes during a series of experimental trials. Marcel agrees that "when stimuli are rendered 'subliminal', the procedure and conditions by which a detection threshold is determined and defined is crucial" (1983a, p.222). He argues, however, that this crucial problem lies not in ensuring that subjects are unaware but in ensuring that the stimulus is not peripherally masked. Marcel implies that the pre- and post- experimental critical SOA procedure is sufficient to ensure that subjects could not have seen a prime during the intervening experimental trials. This claim is open to several criticisms; (i) insufficient trials were used to ensure the accurate determination of the detection threshold (Merikle, 1982; Diaper, Notes 1 and 2), (ii) in any event, thresholds may vary over time (Stevens, 1951), (iii) detection performance on the presence absence task does not necessarily measure awareness during the LDT (Merikle, 1981), (iv) there was no reported direct evidence that subjects were unaware of the primes during the LDT in Marcel's (1983a) Experiment 4.

There have been several failures to replicate Marcel's Experiment 4 (Creighton, Notes 6 and 7; Evett, Note 8; Diaper, Notes 1 and 2), some of which are noted by Marcel (1983a, footnote p.232). These failures to replicate suggest that Marcel's procedure for determining the detection threshold is insufficient. Where a more sensitive threshold is used (i) there is no evidence of associative priming (Experiments 3 and 4; Evett, Note 8; Creighton, Notes 6 and 7), (ii) extensive questioning reveals that subjects can report and identify prime words on some occasions during the experimental trials (Experiment 3).

Fowler et al.'s (1981) replication suffers the same methodological problems. In their Experiment 5 post-experimental questioning appeared to improve the procedure, but its sufficiency in eliciting maximum subject report is open to question (Experiment 4). Experiment 4 demonstrated that nonconscious associative priming effects found using a procedure similar to Fowler et al.'s may have been due to a contribution from consciously processed but unreported primes. It is perhaps worth noting that in Fowler et al.'s Experiment 5, nine out of 20 subjects produced lower post-experimental than pre-experimental critical SOA's. In the present experiments, 13 out of 20 subjects produced lower post experimental SOA's when 40 detection trials were used (Experiment 4), whereas this was the case for only three out of 28 subjects when 100 detection trials were used (Experiment 3). No reduction in post-experimental SOA was reported for any of the 52 subjects tested in Marcel's experiments utilising the critical SOA technique (Marcel, 1983a, Experiments 3, 4, and 5; Marcel, 1980). How Marcel managed to obtain such an apparently stable threshold is unclear. Finally, Yes/No detection accuracy is not perfectly correlated with subject report. In "Blindsight" studies the prima facie case is that report of phenomenal experience determines "being aware". However, Yes/No detection may be highly accurate in cases where there is no report of a phenomenal experience. This will be discussed more fully later.

There are striking similarities between current claims for perception without awareness (Marcel, 1980, 1983a; Fowler et al., 1981) and previous claims for learning without awareness (Greenspoon, 1955; Taffel, 1955). The learning without awareness paradigm apparently demonstrated that subjects learned through "nonconscious" social reinforcement to produce particular designated words or sentences. Awareness was determined on the basis of a brief series of post-conditioning questions. This procedure frequently produced evidence that learning could occur without the subject being conscious of the reinforcing stimulus. When a more extensive regime of questioning was used however, a higher proportion of subjects were found to be aware of the reinforcing stimulus and its relationship to the learning task (Eriksen, 1960, 1962; Speilberger, 1962; Dulany, 1962). From the results of several experiments, Speilberger (1962) concluded:

> Findings suggest that when awareness was inferred on the basis of responses to the BI (brief interview), unaware subjects learned. But when the EI (extended interview) was employed as the basis for inferring awareness, the evidence for conditioning without awareness was found to be largely accounted for by the 16 subjects who failed to verbalise awareness in response to the BI but who did so during the EI (p.78).

These findings support the results of Experiment 4; (i) when subjects were questioned only briefly, there was evidence for associative priming, (ii) more extensive questioning resulted in a higher number of report subjects, and (iii) there was no evidence for nonconscious associative priming for the remaining No Report subjects.

So far there is no published failure to replicate Marcel's Experiment 4. Many people are still assured that Marcel's critical SOA procedure is sufficient to determine lack of awareness. The procedure appears to provide an elegant solution to the problem of examining the processes underlying consciousness. The only published criticism of the procedure is by Merikle (1982). However, there is considerable unpublished criticism of the procedure (Creighton, Notes 6 and 7; Evett, Note 8; Diaper, Notes 1 and 2; Forster and Creighton, Note 3).

5.1.2. Criteria for awareness in "Unconscious Perception"

The pattern masking experiments in Chapters Three and Four are contained within Dixon's category of "unconscious perception", which does not necessitate notions of thresholds. Lack of awareness is defined within Dixon's second criterion where awareness is determined by retrospective subject report. Two procedures were used in most of the experiments in Chapters Three and Four to determine awareness. First, the masked primes were presented under conditions known to reduce detection on some or all trials for most subjects. Second, subjects were carefully questioned to determine their level of awareness of the masked primes. However, the use of subject report as a dependent variable is beset with problems (Natsoulas, 1967; Nisbett and Wilson, 1977; Lieberman, 1979; Evans, 1980a; Morris, 1981b,c; Morris and Hampson 1983). In the present experiments introspective reports of either presence-absence or descriptions of perceptual events within a specific area of the visual field, are regarded as a perceptual report. The present approach endorses Natsoulas' view that there exists a systematic relation of reference between phenomenal (perceptual) reports and perceptual experience. Marcel (1983a) however, notes; "as Nisbett and Wilson (1977) suggest, reports, even of tachistoscopic stimuli or one's own sensation, probably tell us more about people's beliefs about sensation and cognition than about those processes themselves" (p.233). This statement needs qualification; Nisbett and Wilson argue specifically that "there may be little or no direct introspective access to <u>higher order</u> processes" (p.231, emphasis added). They later define higher order processes as "cognitive processes underlying complex behaviours such as judgement, choice, inference and problem soving" (p.232). In other words, Nisbett and Wilson are drawing the distinction, previously made by Natsoulas (1967), between cognitive and perceptual reports. Nisbett and Wilson's argument is aimed primarily at the use of subject report in social psychology, particularly in those cases where it is uncritically used as a basis for inferring underlying processes in attitude studies. They discuss subliminal perception, and in particular a dichotic shadowing experiment by Wilson (1975). In that experiment subject report was used to determine awareness of a tone presented on the unattended channel. Although subjects were apparently unaware of the tone (adopting subject report as criterion to determine awareness), results indicated a distinct familiarity effect displayed by subsequent preferential rating of that tone compared to novel tones. Nisbett and Wilson do not comment on or criticise the use of subject report to determine awareness in this experiment or any other. Ericsson and Simon (1980), on the other hand, argue that introspective responses can and do provide important data on cognitive processes. They outline operational definitions of introspections varying in probablility of accurate report, and discuss the impact of instructions and probe techniques within this definition. Non-directed probing together with the differential measures of awareness which have been used throughout the present experiments are endorsed by Ericsson and Simon (1980). They suggest that:

> Verbal reports, elicited with care and interpreted with full understanding of the circumstances under which they were obtained, are a valuable and thoroughly reliable source of information about cognitive processes. It is time to abandon the careless charge of "introspection" as a means of disparaging such data (p.247).

Several authors have noted that some of the most relevant cognitive processes are unconscious and therefore inaccessible to introspection (Nisbett and Wilson, 1977; Kellogg, 1980, 1982). The results of the present experiments provide evidence for their viewpoint, and indicate that indirect techniques are essential to uncover such processes.

The question of whether reportability is equivalent to other measures of awareness is difficult. Some subjects in the present critical SOA experiments were performing above the 60% correct criterion, often as high as 90% correct, even when they stated that they were guessing. This was true of both trained observers and naive subjects. In other words their awareness as determined by their own reports differed from their awareness measured by performance on the presence absence discrimination task. Some reported claims of "blindsight" demonstrate a similar dissociation. For example, one patient, AB, (Weiskrantz et al., 1974), was able to discriminate with above chance accuracy on several tasks even though he was unable to report awareness of the stimuli in question. Marcel (1982) claims that "nonconscious" semantic priming effects have been demonstrated in a patient with similar injury and deficit. There appears to be a sharp contrast between measures of awareness in the critical SOA technique (Marcel, 1983a), and measures of awareness in cases of blindsight (Marcel, 1982). In the critical SOA technique, at or below chance performance on a presence-absence task is assumed to reflect "nonconscious" processing in a LDT. In blindsight studies, above chance presence-absence performance is assumed to reflect "nonconscious" processing. Campion, Latto, and Smith (1983) have suggested alternate hypotheses to account for the blindsight findings. They accept that a principal defining criterion of such cases is that patients have a lesion which produces a scotoma in which the subjects are unaware of "seeing". One of their main criticisms of blindsight attacks the criteria for awareness used, although their criticism has not been entirely accepted (Clark, 1983; Economos, 1983; Haber, 1983; Morton, 1983; Underwood, 1983). Campion et al. suggest that:

> Acknowledgement of awareness by a subject is a weak piece of evidence because its validity rests on the unjustified assumption that a subject is both able and willing to report accurately on his experiences (p.435, emphasis added).

It is odd that Campion et al. take such a strong position in view of the fact that they themselves use subject introspective report in order to define the limits of the scotoma. While it is healthy to be sceptical about the validity of introspective data under some circumstances, Campion et al. go way beyond the available evidence in suggesting that subjects will normally be insensitive and dishonest.

The position argued in this thesis is that the use of subject introspective report as data is necessary in understanding the problems under investigation within cognitive psychology. A general argument as to whether subject report is invalid in all cases (Campion et al., 1983), or invalid in most cases (Nisbett and Wilson, 1977), or valid in most cases (Ericsson and Simon, 1980; Kellogg, 1980, 1982), is unhelpful. The validity and accuracy of subject introspective report, the effect of prior instructions, the kind of information the subject is asked to report, and the adequacy of the probe techniques, may be assessed separately for each experimental situation.

Three measures were taken to increase the accuracy of subject report in the present experiments. Morris (Morris, 1981c; Morris and Hampson, 1983) has argued recently for similar measures. First, the questioning procedure was intended to be as open and nondirective as possible. Over-specific instructions are known to bias subjects interpretations of their perceptions (Joynson and Newson, 1962). The primary question in the post-trial report procedure asked subjects only for simple reports of awareness. In the post-experimental report procedure the primary question was a simple non-directive request asking subjects to describe their visual experience in their own language at their own speed. Second, the computer programs for running Experiments 5 to 15 were designed to minimise the degree of interaction between experimenter and subject in order to reduce uncontrolled social variables (Orne, 1962a; Rosenthal, 1963). All programs contained instructions for the experiment, knowledge of results, reminders to subjects, practice and experimental trials, and provided data collection and analysis. The effects of verbal and nonverbal cues, intentional or unintentional, were therefore minimised. Third, report was required immediately after the appropriate condition and before any further intervening factors. However, time of report varied across experiments and was confounded with manipulations of level of attention directed at prime detection. When the effect of a minimal level of attention on prime detection was intended, subject report was post-experimental. When the effect of maximal level of attention on prime detection was intended, subject report was post-mask. The assumption was that accuracy of report would be impaired in the post-experimental report procedure compared with the post-trial report procedure. The proportion of No Report was expected to fall as time of report approached stimulus presentation. Table 21 indicates that the distribution of No Report subjects across time of retrospective report is similar for both the anagram and lexical decision tasks.

Table 21

Priming effects from 20 msec backward masked primes, and proportion of No Report subjects and trials, for different manipulations of subject retrospective report in the lexical decision and anagram solving tasks.

Time of Report	% No Report		Priming Effects (msec)	
	Subjects	Trials	Identity	Associated
Lexical decision task				
Post-experimental	87	-	18	7
Post-trial				
(a) Binocular	27	64	33	8
(b) Dichoptic	67	71	27	17
Anagram solving task				
Post-experimental	67	-	2237	816
Post-trial				
(a) Binocular	11	66	2858	947
(b) Dichoptic	58	87	3590	1719
Post-mask, Binocular	40	72	1331	227

It is clear that for both tasks, post-trial questioning produces a higher proportion of Report, both by trials and subjects, than post-experimental questioning under the same mode of presentation. Differences in Report distribution across time of report may be due to several factors; (i) changes in subjects attentional strategies, (ii) failure to provide accurate report post-experimentally, or (iii) variation in instructions may itself affect accuracy of report. With regard to the latter, Haber (1966) has argued that report accuracy is increased with instructions to attend to particular aspects of the stimuli. Whether this is due to perceptual enhancement, or recoding to facilitate recall, is unclear, but higher report accuracy would be predicted for post-trial compared to post-experimental report.

The slight decrease in Report between post-trial (Experiments 8 and 13) and post-mask experiments (Experiment 14) is contrary to that expected. In the manual Yes/No task (Experiment 14) subjects were requested to respond "Yes" if there was "something other than the symbols". The same question was asked in the post-trial report experiments where any positive reply was classed as a Report. In an experimental situation similar to this, Ericsson and Simon (1980) argue that "keypunches are psychologically indistinguishable from verbal response, except that they are made with the finger instead of the mouth (p.216)". If the two responses are taken as equivalent then making report post-mask rather than post-trial did not increase the probability of Report. This makes it unlikely that Report was underestimated in the post-trial case.

Dichoptic presentation appears to provide more effective masking in both the lexical decision and anagram solving tasks. A higher proportion of No Report trials and subjects is obtained, compared with similar stimulus conditions under binocular presentation.

A critical attitude towards the validity of subject retrospective report has been adopted. This has resulted in efforts to increase accuracy of report, manipulations to check report validity, and a restrictive criterion for inclusion in the No Report category. In the present experiments 165 subjects were asked to provide a simple report of awareness of pattern masked words under the various conditions in Experiments 7 to 9 and 11 to 15. Of these, 77 gave No Report data only, and most of the others provided both No Report and Report data. It is possible that some subjects provided either inaccurate or dishonest report, but it is considered that this would amount to only a few cases, if at all. It is extremely implausible that such cases were sufficiently systematic to account for the pattern of priming effects found across the experiments.

Comparison of priming effects and report between Experiments 13 and 15 shows increased priming with decreased probability of report. This is strong evidence against the view that report probability and priming are both measures of a common underlying variable such as "stimulus availability". This point will be discussed more fully in Section 5.3.

Cheesman and Merikle (Note 16) draw a distinction between subjective and objective definitions of awareness. They endorse the view, expressed in this thesis, that awareness can be assessed using a subjective threshold, defined by what the observer reports being able to discriminate. Their results show that words presented at an objective threshold, where forced-choice discrimination is at chance level, provide no evidence of perceptual processing. However, they also show that words presented at a subjective threshold, where observers _claim_ not to be able to discriminate perceptual information, do provide evidence of perceptual processing.

5.2. Priming Effects from single words

5.2.1. Repetition and solution priming

When both prime and target can be clearly seen, repetition and solution priming produce large priming effects in both the LDT and anagram solving tasks. Nonconscious repetition and solution priming also provide significant priming on both tasks, under all experimental manipulations, with one exception (Experiment 1). In all other experiments nonconscious repetition and solution priming effects were both large and significant. These effects were present under conditions adopting (i) the critical SOA technique (Experiment 2), (ii) the least restrictive criteria for awareness (Experiments 7, 11, and 12), (iii) the most restrictive criteria for awareness (Experiment 14), and (iv) appear to increase with prime duration

(Experiment 12). Most important, nonconscious repetition or solution priming was significant under several conditions which did not provide evidence for nonconscious associative priming. Table 21 illustrates priming effects (relative to the unrelated condition) for both tasks under all masking conditions.

5.2.2. Associative priming

When both prime and target can be clearly seen, associative priming produces substantial and significant facilitation on both the lexical decision and anagram solving tasks. In contrast to the pervasiveness of nonconscious repetition priming, nonconscious associative priming was only significant with dichoptic presentation (Experiment 9). In anagram solving, nonconscious associative priming was significant (i) binocularly with long prime durations, and (ii) with dichoptic presentation (Experiments 12 and 15). In all of the other experiments masked associated words appeared to provide some priming effects, although this was not significant for any one experiment. The pattern of associative priming across the twelve experiments which use masked primes suggests that associative priming is often present, even though it is not significant.

The results in general support Marcel's (1983a) claims that nonconscious processing may extend to the semantic system. They also support other findings of nonconscious associative priming (Fowler et al., 1981; Balota, 1983) and nonconscious identity priming (Evett and Humphries, 1981; Humphries et al., 1983, 1984). In addition, the results of the anagram experiments demonstrate that nonconscious priming effects can facilitate the retrieval of words from semantic memory in a complex problem solving task.

Marcel's (1980, 1983b; Marcel and Patterson, 1978) claim that pattern masking interferes with processes subserving conscious representation, but not with all ongoing information processing, is partly supported by the present results. If Marcel's approach is adopted it is easy to suppose that nonconscious processing occurs equally, without selection, and to the highest level of activation for all representations. The present results do not support the view that all stimuli are processed equally to the same level of representation. They indicate instead that nonconscious processing is selective. The way in which this selection might occur is discussed in the following section.

5.3. Locus of priming effects

Evidence from studies of word recognition in normal subjects, and data from neurological patients with reading deficits, indicates that "the lexicon" may be divided into functionally independent subunits (Allport, 1979; Allport and Funnel, 1981; Marcel and Patterson, 1978; Morton and Patterson, 1980; Patterson, 1981; Phillips, Orchard, Doyle, and Allen, Note 10). Visually presented words achieve lexical access and recognition following figure-ground separation; feature analysis; letter identification (Schvaneveldt and McDonald, 1981; Meyer and Schvaneveldt, 1976; Morton, 1969); and analysis of orthographic structure (Estes, 1975; McClelland, 1979). Information flow through the processing system may be either continuous (McClelland, 1979; McClelland and Rumelhart, (1981); Rumelhart and McClelland, 1982) or discrete (Forster, 1979; Morton, 1979,1980).

In Morton's recent logogen models (Morton, 1979; Morton and Patterson, 1980), the visual input logogen which represents each word collects evidence for the presence of that word, receiving information from both the visual analysis system and the cognitive system. Two thresholds for onward transmission have to be exceeded for recognition to occur. Evidence in excess of the first threshold results in code transmission to the cognitive system containing semantic information. Further accumulation of evidence exceeding the second threshold produces transmission of a code to the output logogen system providing the word's phonological code for the subsequent response. Processing up to the logogen units is in parallel but only the maximally excited logogen at any one time is afforded conscious representation. The modality specific (visual, auditory) input and output logogen systems are independent in Morton's model, where separate codes are used for reception and production. Allport's model (Allport, 1979; Allport and Funnell, 1981) differs on this issue; input and output logogen systems are not functionally independent, although they are modality specific. Reciprocal interactions in the latter model between phonological, orthographic, and semantic (cognitive) lexicons provides a multiplicity of processing routes.

The Phillips et al. (Note 10) approach is similar to the above models and to Rumelhart and McClelland's (McClelland and Rumelhart, 1981; Rumelhart and McClelland, 1982) interactive activation model, in that word recognition involves three domains of representation, and activation between and within these domains. The Rumelhart and McClelland model concentrates primarily on contextual effects below word level, although no explicit attempt is made to separate conscious and nonconscious processes. They suggest that "visual input produces partial activation of letters, which in turn produce partial activation of words. These activities then produce feedback to the letter level" (p.60). This automatic reciprocal activation may explain the word superiority effect (Reicher, 1969; Wheeler, 1970) more parsimoniously than the active recovery of records hypothesis put forward by Marcel (1983b). The level of priming facilitation derived from multi-level interaction depends on the number of active pathways initiated by the prime and their physical and semantic relation to the output. Interrelations between the three domains of representation allow automatic recoding from one representational form to another. For example, in the Phillips et al. approach, output phonology can be derived from graphic representations at several levels. In the present experiments, nonconscious repetition or solution priming does not isolate which of the elements in this system provide a locus of priming. Facilitation from priming may be located at the levels of (i) feature analysis, (ii) letter description, (iii) orthographic lexicon, (iv) visual whole word lexicon, (v) phonological lexicon, (vi) semantic system. Although the pattern of results suggest some contribution from lexical or semantic levels, the effects might be partly explained by (i) and (ii) above. However, they cannot be wholly explained in this way because word frequency effects have been demonstrated for masked repetition primes (Evett and Humphreys, 1981; Humphreys et al. 1983), which indicates the involvement of factors subsequent to the letter level. Furthermore, there is evidence that nonconscious solution priming in anagram solving may be affected by word class. In a recent experiment (Phillips et al., Note 10), nonconscious anagram solution priming by concrete nouns provided significantly greater effects than priming by function words. As word class is determined by meaning rather than structure, these solution priming effects reflect automatic access to some part of the semantic system. Considerable further evidence of nonconscious access to the semantic system has been reviewed, although different criteria were used to determine lack of awareness in each of these experiments (Experiments 9, 12, and 15; Fowler et al., 1981; Marcel, 1980, 1983a; Evett and Humphreys, 1981; de Groot, 1983). Nonconscious associative priming in Experiments 9 and 15 in particular provides further strong evidence of automatic access to the semantic system.

Restrictive criteria for awareness have been adopted in order to determine the extent of nonconscious processes in word recognition. However, the notion of a continuum of conscious awareness from entirely unaware to completely aware, may be more appropriate both to normal viewing and in understanding the various "nonconscious" priming effects discussed so far. For example, in Experiment 8, under the most restrictive criteria for awareness, where any report of "something" was considered as Report, there was no evidence for nonconscious associative priming. If, on the other hand, only correctly identified words were considered as Report, "nonconscious" associative priming was significant. Investigators who adopt the latter less restrictive criteria obtain associative priming effects from unidentified primes (Evett and Humphreys, 1981; de Groot, 1983). These findings suggest that part-cue information from words or letters may be affecting task performance. Nonetheless, increasing priming effects in the present experiments are not simply a reflection of increased reportability, or "availabliity" of the prime. The general finding is that priming effects increase with availability, where availability is related to changes in prime duration, or changes in masking conditions (Marcel, 1983a; Carr et al., 1982). However, a dissociation between reportability and priming is indicated by report and priming differences under dichoptic and binocular presentation conditions in the present experiments. In both the LDT and anagram solving tasks reportability of the prime decreases between binocular (Experiments 8 and 13) and dichoptic (Experiments 9 and 15) presentation, while at the same time priming effects increase (see Table 21). Mann Whitney tests were performed to see whether solution or associated priming effects were significantly greater under dichoptic presentation (Experiment 15) compared with binocular presentation (Experiment 13), for 20 msec prime durations only. Subject mean solution and associated priming effects were treated as individual subject data. The increase in priming effect under dichoptic presentation, with a smaller proportion of No Report subjects, is significant for solution priming ($\underline{U}$ (14,12) = 45, $\underline{p}$ < .01 (one tailed)), but not for associative priming. A Chi square comparison of the proportion of No Report trials across the two experiments does not show a significant change in reportability. It therefore seems that reportability can be constant, or even decrease, while solution priming effects on anagram solving increase. This militates against the possibility that "nonconscious" priming effects in the present experiments merely reflect an arbitrary report decision criterion.

The pattern of the results across experiments, and those of Experiment 12 in particular, suggests that nonconscious priming effects in single word recognition may be dependent on "strength" of activation. This strength of activation varies with (i) the number of similar graphemic features and (ii) the semantic relationship between prime and target (cf. Evett and Humphreys, 1981). Most views of nonconscious processing hold that a nonselective and automatic spread of excitation occurs within the processing system (e.g., Marcel, 1983b; Posner and Snyder, 1975) Selection is seen primarily as a function of conscious attention. The results of a series of experiments (Evett and Humphreys, 1981; Humphreys et al., 1983, 1984) show a hierarchy of priming effects in a word naming task where primes were masked to prevent identification. For example they found (1) repetition and associative priming effects, (ii) repetition priming significantly greater than associative priming (as in Experiments 9 and 15), (iii) repetition priming greater than graphemic priming, (iv) graphemic priming from both words and nonwords, (v) graphemic priming increased with the number of common letters, and (vi) graphemic priming was greater for end letter positions. However, Forster and Davis (1984) failed to find graphemic priming effects from masked primes in a lexical decision task. They suggest that graphemic priming may only occur at the short prime-target SOA's tested in the Humphreys et al. series. On the other hand, in the Humphreys et al. experiment graphemic priming may facilitate a naming response via grapheme-phoneme conversion rules, even though it does not significantly affect access to the whole word lexicon in a lexical decision task (Forster and Davis, 1984).

Interpretation of nonconscious priming effects may be aided by viewing the priming process as a result of multi-pathway automatic activation. The number of pathways which can be activated between the prime representation and the target representation will determine the level of target activation. The larger and more pervasive repetition or solution priming effects, compared with associative priming, may thus be explained by the additional structural priming pathways which are activated for repetition and solution priming but not for associative priming.

5.4. Priming effects and awareness in reading

The present results directly address only conscious and nonconscious same identity and associated priming by brief single presentations of centrally fixated words. Priming effects have been useful in demonstrating nonconscious automatic access to meaning, but it is difficult to understand what part nonconscious foveal priming plays in normal reading. Average fixation duration for skilled adult readers is between 200 and 250 msec (Bouma, 1979; Rayner, 1979), much faster than the 600 msec SOA tested in the present experiments. Furthermore, a centrally fixated word is unlikely to be followed by the same word in the same retinal location in normal reading. An associated word may follow, but the likelihood that it will be correctly predicted, or that it will follow immediately will probably be low. Additionally, all the words were associated concrete nouns paired by free recall, such as lion-tiger, man-woman, or arm-leg. However, free recall scores do not necessarily reflect probability of sequential occurrence in written language. Moreover, other words usually mediate between the paired associates even when they do occur sequentially in reading, yet conscious associative priming is either weakened (Davelaar and Coltheart, 1975) or destroyed (Dannenburg and Briand, 1982) by intervening words. The results of the present experiments indicate that word recognition processes may be entirely automatic for centrally fixated words in normal reading. Automaticity at this level allows more capacity for conscious attentional processes involved in comprehension and meaning of the overall text.

The contribution of nonconscious foveal priming as a heuristic for word recognition in normal reading is uncertain. When this thesis was started there was considerable theoretical and empirical support for the view that contextual priming facilitates reading. Recent findings, however, indicate that contextual priming effects, either with or without awareness, have a minimal impact on reading performance. First, it was held that a related sentence context facilitated response to a final (target) word in the sentence (eg. Fischler and Bloom, 1980; Schuberth and Eimas, 1977; Stanovich and West, 1979; West and Stanovich, 1978). In most experiments the target word was also the final word in a sentence and in a context designed to provide high predictability for its occurrence. However, when Stanovich and West (1982) provided a more "normal" sentence context in which the target word was less predictable and nonterminal, they found that contextual priming effects were considerably reduced, and were minimal compared with previous findings.

Second, preprocessing of words in the parafovea was thought to facilitate recognition of that word when it was fixated following a subsequent eye movement (Marcel, 1978; Rayner, McConkie and Zola, 1980). Marcel (1978) suggested that all unattended text was simultaneously and nonconsciously processed to a level of meaning. This claim was not supported by Rayner (1978) who found no evidence for semantic parafoveal priming, either facilitatory or inhibitory. However, Rayner's results indicated that some graphemic priming was provided by parafoveal words, particularly the first few letters. Although initially supported (McConkie, 1979; Rayner et al. 1980), this claim has since been dismissed (McConkie, Zola, Blanchard, and Wolverton, 1982).

Third, it was also held that parafoveal preprocessing was more effective when words were presented to the right of fixation (Bradshaw, 1974; Underwood, 1976, 1977, 1980, 1981; Inhoff, 1982, Inhoff and Rayner, 1980). Underwood has shown both interference (Underwood, 1976, 1977) and facilitation (Underwood, 1981, Underwood, Parry, and Bull, 1978; Underwood and Thwaites, 1982; Underwood, Rusted, and Thwaites, 1983) attributable to related parafoveal primes on a number of tasks. On balance, Underwood's series of experiments tend to show more interference than facilitation provided by parafoveal, unattended and unreported words presented simultaneously to the right of a centrally fixated target word. Conversely, many authors have found that under similar conditions there are no semantic effects, either facilitatory or inhibitory, from parafoveal unattended words

(Inhoff and Rayner, 1980;, Inhoff, 1982; Rayner, 1975; McConkie and Rayner, 1975; Rayner and Bertera, 1979; Rayner, McConkie and Zola, 1980; Paap and Newsome, 1981; Stanovich and West, 1983).

Fourth, several authors (Haber and Haber, 1981ab; Haber, Haber and Furlin, 1983; Monk and Hulme, 1983) have suggested that word shape information indicated by supraletter feature information such as patterns of ascending and descending features, and density of distribution, provides semantic information which facilitates subsequent foveal recognition. Although word shape facilitates recognition using these criteria, overall word shape on its own does not (Paap, Newsome, and Noel, 1984).

Many findings, therefore, fail to show evidence for automatic semantic priming effects in experiments which investigate word recognition in situations comparable with normal reading. These findings provide difficulty for theories of reading which require semantic preprocessing of parafoveal or peripheral words (Hochberg, 1970; Neisser, 1967). McConkie (1979) and Rayner (1979), argue that direct access to meaning only occurs at fixation. McConkie suggests that eye movements to new locations in normal reading are directed primarily by the lack of sufficient information resulting from parafoveal analysis of that area. In Rayner's (1979) view, a combination of sequential redundancy of the text and parafoveal identifaction of the size of the next word determines the location of the next fixation, and not preprocessed semantic information.

The overal evidence indicates that direct access to meaning by parafoveal words does not occur in normal reading. The question remains of whether foveal word priming in the present experiments reflects a more general facilitatory mechanism for object recognition. The graphic characteristics of letters used in most of the preceding experiments may be described largely in terms of high spatial frequencies. Parafoveal primes were usually presented between one degree and five degrees from the fovea, although visual angle was as much as eight degrees in one study (Underwood, 1977). However, the processing capability of the system decreases with angular distance from the fovea (Riggs, 1965). Sensitivity to high spatial frequencies is selectively reduced with foveal eccentricity (Campbell and Green, 1965; Campbell and Gilchrist, 1966; Daitel and Green, 1969; Sharpe and Tolhurst, 1973) by a factor of ten between the fovea and 16 degrees into the periphery (Hilz and Canonius, 1974). Failure to achieve parafoveal word priming effects may be due to the high spatial frequency cutoff which reduces the ability for early visual analysis of letters and perhaps letter groups. The low frequency word shape information which is available in the parafovea and periphery does not appear to facilitate word recognition.

Several authors have found semantic priming effects for word and picture priming, both with and without awareness (Sperber et al., 1979; McCauley et al., 1980; Carr et al., 1982; Smith and Magee, 1980). According to Carr et al. (1982) both word and picture primes access a common semantic code. In their experiments, when primes were masked to prevent identification, neither associated word primes nor associated picture primes facilitated word naming. On the other hand, picture naming was considerably facilitated by masked associated pictures primes. Carr et al. argue that this priming advantage is due to the confounding of physical and semantic similarity which is common between associated pictures but not between associated words. They interpret their overall results within a simple perceptual effort hypothesis; the degree of similarity between an input and its representation can determine both the degree of automaticity of processing and the amount of facilitation provided by priming.

Carr et al.'s finding that subthreshold pictures provide substantial facilitation when subthreshold words provide none at all, may indicate an underlying function for priming which has produced the word repetition and solution priming effects. Foveal word priming may be only an unimportant consequence of a general pattern recognition heuristic. The facilitation provided by foveal identity priming in a normal object environment under normal viewing conditions may provide ongoing facilitation for same object recognition on subsequent scans, and aid the preservation of object constancy. Parafoveal processing of common objects may benefit from the additional information provided by colour, depth, motion, and by low spatial frequency analysis. Parafoveal identification of objects will be limited by the discriminative capacity of the underlying system at that point. Low spatial frequency information allows only minimal detail, but this may be sufficient to provide a contextual reference. The facilitatory effect of preprocessing of foveal, parafoveal, and peripheral primes on object recognition has yet to be determined.

In summary, the nonconscious automatic foveal priming effects on single word recognition in the present experiments do not appear to be generalisable to studies of normal reading. These foveal priming effects may, however, reflect a more general heuristic in object recognition. Parafoveal object recognition may be (i) less dependent on high spatial frequency analysis, and (ii) supplemented by additional processing of colour, depth, and motion. Clearly it is important to know what types of information are automatically and nonconsciously available for particular classes of information as foveal eccentricity increase. The suggestion is that word processing and picture processing are differently affected by masking under foveal presentation, and that differences in the amount of information available will increase with foveal angle. It would be useful to determine relative priming effects from words, pictures, and objects at different locations and foveal eccentricity. The masking techniques developed in the present series of experiments could be modified to investigate nonconscious automatic priming for these different classes of visual stimuli.

5.6. Priming, awareness, and attention

Marcel's (1983a,b) experiments and theory provided much of the impetus for the present thesis. His claim for nonconscious access to the semantic system is partly supported by the present results. So too is his claim that backward pattern masking can prevent conscious perception while allowing some underlying nonconscious processing to continue. His call for a rejection of the Identity Assumption is thus supported. The mechanisms underlying visual perception cannot be uncovered by relying on conscious perceptual report alone. However the present results do not map entirely onto Marcel's theoretical model. First, Marcel's theory proposes that perceptual data are processed automatically and nonconsciously to the highest level of description available. The data is automatically redescribed into all codes available to the processing system. The present results indicate that nonconscious processing and redescription of words is limited and appears to be selective. Direct (repetition or solution) primes and associated primes do not afford the same degree of facilitation at the same stimulus energy level. Neither do function and concrete words.

Second, in Marcel's theory consciousness requires an active process of matching hypotheses about the stimulus with records recovered from the initial processing of that stimulus. Because recovery acts in the opposite direction to the information processing flow, information reflecting the meaning of a stimulus will be available to consciousness before information describing its structure. The results of Marcel's (1983a) Experiment 1 initially provided substantial empirical support for this view, although criticisms of his method together with failures to replicate suggest that these results are not dependable. Dixon (1971, 1981) also holds that meaning dominates structure, particularly in the recognition of degraded stimuli. One example he provides is Worthington's (1964) experiment where rate of dark adaption sufficient to detect a small, dimly lit screen, was dependent on what was written on the screen. The time taken to detect the screen was longer for presentations of socially unacceptable (taboo) words than neutral words, even though subjects never reported seeing a word displayed. Worthington claims that his results demonstrate (i) nonconscious access to the meaning of words, and (ii) that meaning can dominate structure in what is represented in consciousness. Unfortunately, this experiment is also difficult to replicate (Weintraub and Krantz, 1968; Orchard, Note 11). Overall there appears to be little support for the claim that meaning dominates structure in nonconscious automatic processing.

The pattern of results of the present experiments and others suggest that consciousness of a stimulus may be more a passive result of nonconscious automatic processing (cf. Morton, 1969; Deutsch and Deutsch, 1963; Shallice, 1972, 1978), rather than an active process of recovery (Marcel, 1983b). The same pattern of priming effects is displayed across a number of tasks independent of whether or not subjects are aware of the stimuli: (i) nonconscious identity priming produces better performance than nonconscious associative priming in word recognition (Experiment 9), (ii) nonconscious identity priming produces better performance than nonconscious associative priming in retrieving words from memory in a problem solving task (Experiment 15), (iii) conscious priming effects show the same patterns of facilitation.

Nonconscious processing may be seen as both passive and selective. Selectivity is determined by structural characteristics of the visual information processing system. Some aspects of these are probably predetermined (e.g., opitico-retinal structure), while others may be learned (e.g., word processing). Selection appears to depend on (i) visual acuity subject to optical limitations, (ii) visual acuity determined by density and distribution of retinal receptors, (iii) non-homogeneous differences in spatial frequency sensitivity contingent on foveal eccentricity, (iv) activation level of logogen or similar units determined by prior contextual priming. The present experiments suggest that the level of contextual priming will be determined by the number of shared physical attributes, and by degree of association. Conscious awareness of a word is seen as a passive product, automatically determined by the most highly activated logogen unit. Marcel argues against this point of view and suggests that activation alone is insufficient to produce awareness. In his (1983a) Experiment 5, repetition of an associated prime increased priming effects but repetition did not increase probability of report. In a related experiment, Doyle (Note 12) has shown that nonconscious repetition of an identity prime increased priming in the anagram solving task, although repetition of a nonconscious associated prime under the same conditions did not facilitate anagram solving. Doyle's results support the present finding that evidence for nonconscious associative priming is difficult to achieve under conditions which provide substantial nonconscious solution priming effects. The additional priming effect produced by multiple repetitions in Marcel's and Doyle's experiments support the earlier argument that facilitation may summate across the number of operative processing routes used. Failure to achieve a conscious percept following a number of repetitions suggest that conscious perception of a word requires activation of a lexical unit by a number of different routes, particularly perhaps those subserving structural analysis. In terms of Mortons (1979) model, input of a semantic code to the output logogen can be insufficient to produce a phonological code for output.

One aspect of Marcel's view of consciousness is particularly difficult to understand. He argues that consciousness of a perceptual stimulus is the result of an active recovery and verification process. In discussing the relationship of hypotheses and records to conscious percepts he makes several assumptions (Marcel, 1983b, p.247). Three of these are:

> (g) We are unaware of the processes by which hypotheses <u>are</u> <u>chosen</u> for testing and by which they are tested...
>
> (b) (Consciousness) involves the parallel testing of the subset of the activated perceptual hypothesis <u>at</u> <u>the</u> <u>chosen</u> <u>level</u> against appropriate records...
>
> (a) <u>We</u> <u>choose</u> at what level to be conscious.
> (1983b, p.247, emphasis added).

The initiating process in this procedure is unclear, and the argument appears to be circular. The latter assumption is particularly tautological. In what way can "We", presumably "Self", be dissociated from "to be conscious"? In what way can we directly affect our level of consciousness? This type of misleading argument was noted earlier in reference to Atkinson and Shiffrin's description of attention and STM. Clearly the concept "We" is insufficently described to benefit any understanding of visual information processes. Nonetheless many similar descriptions and definitions of attention, awareness, and consciousness, invoke "the subject" as an operative process within the information flow. To be conscious necessitates being aware of something, even if it is only a minimal Cartesian statement. Consciousness and awareness may be seen as synonymous in this respect. It may be argued that attention, on the other hand, can be controlled, although under some circumstances attention may be demanded, as in an orienting response. However, attention can be directed to a particular modality or location (Duncan, 1981), and the spread or span of attention can be modulated to include one or several operations. In this sense attention is an intentional act, a result of some conscious control process, and not an initiating process itself. In other words, consciousness is given, and does not control itself, although attention may be allocated. Marcel's circular statement above may be improved by substituting "attention" for "conscious" - "We choose at what level to attend". In the present experiments instructions were intended to induce subjects to adopt different levels of attending to the "space between the arrows". Variations in instructions, and presumably, levels of attention directed at the appropriate space, resulted in variations in perceptability. Although subjects were looking at the same space on each manipulation, what they saw appeared to depend upon how much attentional effort they put into it (cf. Kahneman, 1973).

Three broad aspects of consciousness were reviewed earlier, (i) consciousness as a control process, (ii) the capacity of consciousness, and (iii), the relationship between conscious representations and underlying nonconscious automatic processes.

First, consciousness as a control process. Although many authors discuss this approach, it is often inextricably linked to capacity measures of attention, and to processes of selection. According to some theories however, conscious control processes may be separable from attention. In Shallice's (1972) view for example, consciousness is the "selector input" which determines which action system to put into effect, and to set the goal for that action system. Presumably the allocation of attenton to specific task demands is also determined by the selector input. Sperling's (1967) approach is similar. He argues that consciousness may be equated with a "scanner" which controls subsequent processing operations. Posner (1978), in a view similar to Shallice's argued that conscious awareness represents a control process which plays a specific identifiable role in the organisation of information processing for particular task requirements. Atkinson and Shiffrin (1974), and Marcel (1983b), imply the central importance of control processes by invoking "the subject" as a controlling and directing agency. Mandler (1975) was less clear on this issue, suggesting that consciousness "permits" the "choice systems" to act upon the contents of focal attention.

It is the control aspect of consciousness which appears to be related to Dennett's (1979) attempt to introduce a concept of consciousness "loosely correlated with a sense of self" into cognitive psychology. Several authors have noted the resistance within cognitive psychology to allow that the concepts of "self" or "the subject" may be useful as descriptors of effective processes within the information processing flow (Claxton, 1980; Allport, 1980; Dennett, 1979). Nonetheless, both of these concepts have been widely used in theories of attention (Atkinson and Shiffrin, 1974), and consciousness (eg. Marcel, 1983b; Duncan, 1980, 1981). In other theories the same concepts are only thinly disguised by programming metaphor (Shallice, 1972), or loose computer analogy as in the CPU of Baddeley's Working Memory theory. The resistance to the idea that phenomenology may be part of information processing is understandable in view of the legacy of the Behaviourist tradition and the failure of earlier Introspectionist approaches to perception and cognition. However, the continued reappearance of phenomenological concepts in information processing theories suggests that some account of the effect of "the person" on how that person acts and perceives is necessary.

The second, capacity view of consciousness, related to studies of Short Term or Working Memory (Atkinson and Shiffrin, 1974; Mandler, 1975) appears to confuse control and content in a way similar to that discussed above. Atkinson and Shiffrin, for example, invoke "the subject" directly as the controlling process in transfer of the contents of STM to LTM.

In the third aspect of consciousness, recent work on clarifying the distinction between conscious and nonconscious processes indicates that visual analysis and discrimination can proceed automatically to a level where the meaning of words and pictures is derived, with or without conscious representation (Carr, et al., 1982; Marcel, 1983ab). The relationship between conscious and nonconscious processing is also central to the debate on "Early" vs. "Late" theories of selective attention. The results of the present experiments unambiguously support "Late" theories which posit that full identification of stimulus attributes can occur prior to selection for attention (Deutsch and Deutsch, 1963; Duncan, 1980, 1981). In Duncan's "Late" selection theory, stimulus characteristics such as form, position, colour, size, and classification, are all nonconsciously available at a "first level" of representation. However,

> "To allow a report (or to reach consciousness), a stimulus representation must be chosen ("selection schedule") from those present at the first level and passed through a "limited capacity system" to the "second level". Phenomenally, this would correspond to directing attention to the stimulus. (Duncan, 1981, p.91, (original punctuation)).

Duncan states earlier (p.90) that it is "the person" who "directs attention". The selection schedule "interviews" each first level representation to determine whether it is relevant to the current task before admitting that representation into the limited capacity system for subsequent phenomenal representation. The way in which the selection schedule is effected in information processing terms is left undisclosed, as is the psychological correlate of the selection schedule. What Duncan appears to be saying is that consciously knowing about the task requirements automatically produces an appropriate nonconscious selection schedule in order to produce task relevant alternatives (only) for conscious representation. In some ways this is similar to Marcel's suggestion that conscious decisions of choice determine the level of attention. In other words the entirely phenomenological process of thinking appears to affect decision processes involved in the phenomenal representation of perceptual stimuli.

It may be possible to discuss the effect of conscious cognitive processes involved in the perception of words in terms of priming. The results of the present experiments indicate that nonconscious priming effects are selective. This "structural" selectivity appears to operate automatically and provides a nonhomogeneous matrix of facilitation within the logogen system. In addition, the anagram experiments demonstrate that conscious cognitive processes involved in anagram solving are affected at some point by prior visual presentation of a word related to the solution, as well as the solution itself. Memory search processes, therefore, appear to be sensitive to raised activation levels within the lexical or semantic systems, and benefit from the facilitation provided. Perhaps this facilitatory effect is reversible. Conscious cognitive processes in thinking about a word or a category may themselves nonconsciously provide raised activation in the relevant lexical units, providing facilitation for subsequent conscious perceptual recognition of that particular word or category. Reciprocal facilitatory effects from conscious cognitive processes and nonconconscious automatic perceptual processes may provide a further means of automatic selection for consciousness. Reciprocal facilitation appears to offer a simpler alternative for the processes of selection than the complexities involved in Duncan's nonconscious "selection schedules". "Expectancy effects " for example, may be the result of raised activation levels in lexical or semantic units representing selected stimuli as a direct consequence of consciously thinking about the relevant task. Morton's recent logogen models, although designed to account primarily for perceptual processes in word recognition, allow that input from the semantic system can provide raised activation levels in logogen units. Accommodation within Morton's logogen model requires the assumption that cognitive processes involved in thinking are similar to processes involved in visual or auditory perception. Levels of activation in logogen units may therefore be a composite product of automatic facilitation from cognitive as well as perceptual processes. Although this notion is highly speculative, it attempts to confront the issue of whether conscious processes themselves indirectly affect subsequent conscious representations. Similar ideas appear to be implied by several theorists already discussed, although the issue is often clouded by oblique reference.

Irrespective of whether the above notion is useful to an understanding of the relationship between conscious and nonconscous processing, it appears that a decision must be made within cognitive psychology on what to do with the concept of the "Self" or "The Person". Clearly there are profound philosophical and empirical problems in working out such relationships, but as Dennett (1979) and Searle (1984) have argued, the solutions are necessary in order for psychologists to converse adequately amongst themselves, and explain clearly to the layman what it is that we are trying to explain.

5.6. Conclusions

The empirical results from the present series of lexical decision and anagram solving tasks indicate that nonconscious priming is selective. Nonconscious priming is not found under all conditions even when the stimulus is centrally represented (i.e., centrally masked, as in Experiment 1). Brief or degraded stimuli may be able to produce functionally effective activation of some representations but not others. This differential activation produces a situation where direct (repetition or solution) priming is effective when associative priming is not. The results of other experiments support selectivity in priming, and indicate that selectivity can also occur (i) prior to the whole word lexicon (Humphreys et al., 1983, 1984), (ii) subsequent to the whole word lexicon (Evett and Humphreys, 1981; Phillips et al., Note 9), and (iii) within the semantic system (de Groot, 1983). Current approaches to word recognition assume a number of different pathways between hierarchically and heterarchically related processing nodes. Marcel (1983b) argues that all pathways which exist are automatically and nonconsciously utilized in priming:

> All sensory data impinging however briefly upon receptors sensitive to them is analyzed, transformed, and redescribed, automatically and quite independently of consciousness, from its source form into _every_ other representational form that the organism is capable of representing, whether by nature or acquisition (p.244, emphasis added).

The assumption appears to be that priming is ubiquitous and produces homogeneous nonconscious activation. This view does not explain the present results which clearly indicate heterogeneous priming effects dependent on prime-target relationship. It is proposed that nonconscious facilitation is a heterogeneous matrix of activation of different levels in different relevant representations. Priming depends in part on the number of pathways available between prime representation and target representation. The priming effect from prime to target may be summative across the number of pathways used. This view would predict (i) larger priming effects for direct than associative priming, and (ii) better concrete word priming than function word priming.

One problem with the general view that parallel nonconscious automatic processing fully identifies the meaning of all stimuli, as in some "Late" theories of selective attention for example, is the procedure by which some stimuli are "accepted" for representation in consciousness and others are "rejected". Marcel (1983b) has suggested that consciousness equates with an active process of recovery of records and verification of hypotheses. He implies that nonconscious processes can be selective, when he says: "We are unaware of the processes by which hypotheses are chosen for testing and by which they are tested" (1983b, p.247). Duncan (1980, 1981) suggests that a nonconscious "selection schedule" selects task relevant stimuli for a limited capacity channel and representation in consciousness. Both views imply an active process of nonconscious selection for conscious representation, but neither is clear as to how this process operates. It may be possible to view consciousness as, at least in part, a result of passive selective activation operating nonconsciously, where a threshold criterion determines access to consciousness. This suggests the hypothesis that conscious attentional processes may also influence the pattern of nonconscious priming which contributes to activation levels (in nodes such as logogen units in word recognition, for example). Conscious representation is thus the result of activation in representational nodes which receive input from multiple sources. This activation level is determined partly by priming, and partly by the results of current perceptual processing. It is this pattern of heterogeneous nonconscious activation which provides the basis for further conscious attentional selection.

REFERENCE NOTES

(1) Diaper, D. (1982). Central Backward Masking and the Two Task Paradigm. Doctoral Dissertation. University of Cambridge.

(2) Diaper, D. (1984). An experimental demonstration that subliminal perception depends on relative task sensitivity. Unpublished manuscript.

(3) Forster, P.M., & Creighton, P.U.B. (1982). Awareness thresholds in perceptual processing. Unpublished manuscript.

(4) Marcel, A.J. (1974). Perception with and without awareness. Paper presented to a meeting of the Experimental Psychological Society, Stirling, Scotland.

(5) Slade, R. (1979). Supportive evidence of Marcel's reinterpretation of the role of pattern masking in visual word perception. Honours thesis, Dartmouth College, NH.

(6) Creighton, P.U.B. (1980). Unconscious priming effects. Paper presented to the BPS Workshop on Conscious and Unconscious Processes in Reading, Birkbeck College, University of London.

(7) Creighton, P.U.B. Doctoral dissertation in preparation. University of Cambridge.

(8) Evett, L.J. (1981). A study of the information available from briefly presented pattern masked words. Doctoral dissertation. University of Bristol.

(9) Chambers, S. (1983). Manuscript in preparation. Deakins University, Australia. Quoted in Marcel (1983a, p.232).

(10) Phillips, W.A., Orchard, G.A., Doyle, M., & Allan, J.M. (1984). A function word deficit in reading without awareness. Unpublished manuscript, University of Stirling.

(11) Orchard, G.A. (1978). Non-differential rates of dark adaptation to taboo and neutral words. Honours dissertation, University of Warwick.

(12) Doyle, M. (1983). Some limitations on the priming ability of unreported primes: Anagram solutions are facilitated by unreported solution primes but not unreported associated primes. Honours dissertation, University of Stirling.

(13) Hales, D. (1980). Apple II Timing (Mountain Hardware clock) and VIA I/O Routine. Psychology Department, Queen's University of Belfast.

(14) Sperling, G. (1970). Stereoscopic visual displays: Principles, viewing devices, alignement procedures. Paper presented at NATO Advanced Studies Institute, University of Sheffield.

(15) Wilson, W.R., (1975). Unobtrusive induction of positive attitudes. Unpublished Doctoral dissertation, University of Michigan.

(16) Cheesman, J., & Merikle, P.M. (1985). Word recognition and Consciousness. To appear in D. Besner, T.G. Waller, & G.E. MacKinnon (Eds.), Reading research: Advances in theory and practice: Vol.5. New York: Academic Press.

REFERENCES

Allport, D.A. (1977). On knowing the meaning of words we are unable to report. The effects of visual masking. In S. Dornic (Ed.), Attention and Performance VI. Hillsdale, NJ: Erlbaum.

Allport, D.A. (1979). Word recognition in reading. In P.A. Kolers, M.E. Wrolstad & H. Bouma (Eds.), Processing of visible language (Vol. 1), New York: Plenum Press.

Allport, D.A. (1980). Attention and Performance. In G. Claxton (Ed.), Cognitive Psychology. London: Routledge & Kegan Paul.

Allport, D.A., & Funnell, E. (1981). Components of the mental lexicon. Philosophical Transactions of The Royal Society of London: B. Biological Sciences, 295, 397-410.

Atkinson, R.C. & Shiffrin, R.M. (1968). Human memory: A proposed system and its control processes. In K.W. Spence & J.T. Spence, Advances in the psychology of learning and motivation research and therapy (Vol. 2). New York: Academic Press.

Atkinson, R.C. & Shiffrin, R.M. (1971). The control of short-term memory. Scientific American, 225, 82-91.

Balota, D.A. (1983). Automatic semantic activation and episodic memory encoding. Journal of Verbal Learning and Verbal Behaviour, 22, 88-104.

Betchtel, W., & Richardson, R.C. (1983). Consciousness and complexity: Evolutionary perspectives on the Mind-Body problem. Australasian Journal of Philosophy, 61(4), 30-51.

Becker, C.A. (1980). Semantic context effects in visual word recognition. Memory and Cognition, 8(6), 493-512.

Becker, C.A., & Killion, T.H. (1977). Interaction of visual and cognitive effects in word recognition. Journal of Experimental Psychology. Human Perception and Performance, 5, 527-545.

Bousfield, W.A., Cohen B.H., Whitmarsh G.A, & Kincaid W.D. (1961). The Connecticut free association norms. University of Connecticut. Studies on the Mediation of Verbal Behaviour, Technical Report No. 35.

Bradshaw, J.L. (1974). Peripherally presented and unreported words may bias the perceived meaning of a centrally fixated homograph. Journal of Experimental Psychology, 103, 1200-1202.

Campbell, F.W. and Green, D.G. (1965). Optical and retinal factors affecting visual resolution. Journal of Physiology, 181, 576-593.

Campbell, F.W. and Gubisch, R.W. (1966). Optical quality of the human eye. Journal of Physiology, 186, 558-578.

Campion, J., Latto, R., & Smith, Y.M. (1983). Is Blindsight an effect of scattered light, spared cortex, and near threshold vision? The Behavioral Brain Sciences, 6, 423-486.

Carr, T. H. (1979). Consciousness in models of human information processing: Primary memory, executive control, and input regulation. In G. Underwood & R. Stevens (Eds.), Aspects of consciousness. London: Academic Press.

Carr, T.H, & Bacharach, V.R. (1976). Perceptual tuning and conscious attention: Systems of input regulation in visual information processing. Cognition, 4, 281-302.

Carr, T.H., McCauley C., Sperber R.D. & Parmelee C.M. (1982). Words, pictures and priming: On semantic activation, conscious identification, and the automaticity of information processing. Journal of Experimental Psychology: Human Perception and Performance, 8(6), 757-775.

Clark, A. (1983). How to establish a difference in function. The Behavioral Brain Sciences, 6, 451.

Cohen, J.L. (1968). Effect of letter frequency on anagram solution times. Psychonomic Science, 11(2), 68-79.

Claxton, G. (1980). Cognitive psychology: a suitable case for what sort of treatment? In G. Claxton (Ed.), Cognitive Psychology. London: Routledge & Kegan Paul.

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

Coltheart, M. (1981). Psycholinguistic database. London: Medical Research Council.

Corteen, R.S., & Dunn, D. (1974). Shock associated words in a non-attended message: a test of momentary awareness. Journal of Experimental Psychology, 102, 1143-1144.

Corteen, R.S., & Wood, B. (1972). Autonomic responses to shock associated words. Journal of Experimental Psychology, 94, 308-313.

Daitch, J.M. and Green, D.G. (1969). Contrast sensitivity of the human peripheral retina. Vision Research, 9, 947-952.

Dannenbring, G.L., & Briand, K. (1982). Semantic priming and the word recognition effect in a lexical decision task. Canadian Journal of Psychology, 36(3), 435-444.

Davelaar, E, & Coltheart, M. (1975). Effects of interpolated items on the asscoiation effect in lexical decision tasks. Bulletin of the Psychonomic Society, 6, 269-272.

Dennett, D.C. (1981). Towards a Cognitive Theory of Consciousness. In D. Dennett (Ed.), Philosophical essays on mind and psychology. Brighton: Harvester.

Deutsch, J.A., & Deutsch, D. (1963). Attention: some theoretical considerations. Psychological Review, 70, 80-90.

Dewing, K., & Hetherington, P. (1974). Anagram solving as a function of word imagery. Journal of Experimental Psychology, 102, 764-767.

Dixon, N.F. (1971). Subliminal Perception: The nature of a controversy. London: McGraw-Hill.

Dixon, N.F. (1981). Preconscious processing. Chichester: Wiley.

Dominowski, R.L. (1966). Anagram solving as a function of letter moves. Journal of Verbal Learning and Verbal Behaviour, 5, 107-111.

Dominowski, R.L. (1967). Anagram solving as a function of bigram rank and word frequency. Journal of Experimental Psychology, 75, 299-306.

Dominowski, R.L., & Ekstrand, B.R. (1967). Direct and Associative priming in anagram solving. Journal of Experimental Psychology, 74(1), 84-86.

Dulany, D.E. (1962). The place of hypotheses and intensions: An analysis of verbal control in verbal conditioning. In C.W. Eriksen (Ed.), Behaviour and awareness. Durham, NC: Duke University Press.

Duncan, J. (1980). Perception of simultaneous stimuli. Psychological Review, 87(3), 272-300.

Economos, J. (1983). Direct awareness and inference. The Behavioral Brain Sciences, 6, 452.

Ellis, A.W., & Marshall, J.C. (1978). Semantic errors or statistical flukes? A note on Allport's "On knowing the meaning of words we are unable to report". Quarterly Journal of Experimental Psychology: Human Experimental Psychology, 30, 569-575.

Erdelyi, M.H. (1974). A new look at the New Look: perceptual defence and vigilance. Psychological Review, 81, 1-24.

Ericsson, K.A., & Simon, H.A. (1980). Verbal reports as data. Psychological Review, 87, 215-251.

Eriksen, C.W. (1960). Discrimination and learning without awareness: A methodological survey and evaluation. Psychological Review, 67, 279-300.

Eriksen, C.W., (1962). Figments, fantasies and follies: A search for the subconscious mind. In C.W. Eriksen (Ed.), Behaviour and awareness. Durham, NC: Duke University Press.

Evans, J.St.B.T. (1980a). Introspective reports of cognitive processes: A critique. Bulletin of the British Psychological Society, 33, 32-33.

Evett, L.J., & Humphreys, G.W. (1981). The use of abstract graphemic information in lexical access. Quarterly Journal of Experimental Psychology: Human Experimental Psychology, 33A(4), 325-350.

Fischler, I. (1977a). Associative facilitation without expectancy in a lexical decision task. Journal of Experimental Psychology: Human Perception and Performance, 3, 18-36.

Fischler, I. (1977b). Semantic facilitation without association in a lexical decision task. Memory and Cognition, 5(3), 335-339.

Fischler, I., & Bloom, P.A (1980). Rapid processing of the meaning of sentences. Memory & Cognition, 8, 216-225.

Fischler, I., & Goodman, G.O. (1978). Latency of associative facilitation in memory. Journal of Experimental Psychology: Human Perception and Performance, 4, 445-450.

Forster, K.I., (1979). Levels of processing and the structure of the language processor. In W.E. Cooper & E. Walker (Eds.), Sentence processing: Psycholinguistic studies presented to Merrill Garrett. Hillsdale, NJ: Erlbaum.

Forster, K.I., & Davis, C. (1984). Repetition priming and frequency attenuation in lexical access. Journal of Experimental Psychology: Learning, Memory, and Cognition, 10(4), 680-698.

Fowler, C.A., Wolford, G., Slade, R., & Tassinary, L. (1981). Lexical Access with and without awareness. Journal of Experimental Psychology: General, 110(3), 341-362.

Freud, S. (1927). The Ego and the Id (Republished). New York: Norton. (1960).

Gilhooley, K.J., & Johnson, C.E. (1978). Effects of solution word attributes on anagram difficulty: A regression analysis. Quarterly Journal of Experimental Psychology. Human Experimental Psychology. 30, 57-70.

Greenspoon, J. (1955). The reinforcing effect of two spoken sounds on the frequency of two responses. American Journal of Psychology, 68, 409-416.

de Groot, A.M.B. (1983). The range of automatic spreading activation in word priming. Journal of Verbal Learning and Verbal Behaviour, 22, 417-436.

de Groot, A.M.B. (1984). Primed lexical decision: Combined effects of the proportion of related prime target pairs and the stimulus onset asynchrony of prime and target. Quarterly Journal of Experimental Psychology, 36(2), 253-280.

de Groot, A.M.B., Thomassen, A.J.W.M., & Hudson, P.T.W. (1982). Associative facilitation of word recognition as measured from a neutral prime. Memory & Cognition, 10(4), 358-370.

Haber, R.N. (1966). Nature of the effect of set on perception. Psychological Review, 73, 335-351.

Haber, R.N. (1983). The two visual system hypothesis loses a supporter. The Behavioral Brain Sciences, 6, 453.

Haber, R.N. & Haber, L.R. (1981a). The shape of a word can specify its meaning. Reading Research Quarterly, 13, 334-345.

Haber, R.N. & Haber, L.R. (1981b). Visual components of the reading process. Visible Language, 15, 147-182.

Haber, L.R., Haber, R.N., & Furlin, K.R. (1983). Word length and word shape as sources of information in reading. Reading Research Quarterly, 18, 165-189.

Helmholtz, H., von. (1867). Treatise on physiological optics (3 Vols.). J.P.C. Southall (Ed.). (Republished 1962). New York: Dover.

Hilz, R., and Cavonious, C.R. (1974). Functional organisation of the peripheral retina: sensitivity to periodic stimuli. Vision Research, 14, 1333-1337.

Hirst, W., Spelke, E.S., Reaves, C.R., Caharack, G., & Neisser, U. (1980). Dividing attention without alternation or automaticity. Journal of Experimental Psychology: General, 109(1), 98-117.

Hitch, G.J. (1980). Developing the concept of working memory. In G. Claxton (Ed.), Cognitive Psychology. London: Routledge and Kegan Paul.

Hochberg, J. (1970). Attention, organisation and consciousness. In D.I. Mostofsky (Ed.), Attention: Contemporary theory and analysis. New York: Appleton-Century-Crofts.

Humphreys, G.W. (1981). Direct vs. indirect tests of the information available from masked displays: What visual masking does and does not prevent. British Journal of Psychology, 72, 323-330.

Humphreys, G.W., Evett, L.J., & Taylor, D.E. (1983). Automatic phonological priming in visual word recognition. Memory and Cognition, 10(6), 576-590.

Humphreys, G.W., Quinlan, P.T., & Evett, L.J. (1984). The working papers of the London Psycholinguisitic Research Group (in press).

Inhoff, A.W. (1982). Parafoveal word perception: A further case against semantic preprocessing. Journal of Experimental Psychology: Human Perception and Performance, 8, 137-145.

Inhoff, A.W., & Rayner, K. (1980). Parafoveal word perception: A case against semantic preprocessing. Perception & Psychophysics, 27, 457-464.

Jablonski, E.M., & Mueller, J.H. (1972). Anagram solution as a function of instructions, priming and imagery. Journal of Experimental Psychology, 94, 84-89.

James, W. (1890). The principles of psychology (Vol 1). New York: Holt.

Joynson, R.B., & Newsome, L.J. (1962). The perception of shape as a function of inclination. British Journal of Psychology, 12, 221-230.

Kahneman, D. (1973). Attention and effort, Englewood Cliffs, NJ: Prentice-Hall.

Kahneman, D., & Chajczyk, D. (1983). Tests of the automaticity of reading: Dilution of the Stroop Effect by color-irrelevant stimuli. Journal of Experimental Psychology: Human Perception and Performance, 9(4), 497-501.

Kahneman, D., & Treisman, A. (1983). Changing views of attention and automaticity. In R. Parasuraman & J. Beatty (Eds.), Varieties of Attention. New York: Academic Press.

Keele, S.W. (1968). Movement control in skilled motor performance. Psychological Bulletin, 70, 387-403.

Keele, S.W. (1969). Repetition effect: A memory dependent process. Journal of Experimental Psychology, 80, 243-248.

Keele, S.W. Attention and human performance. Pacific Palisades, Calif,: Goodyear 1973

Kellogg, R.T. (1980). Is conscious attention necessary for long term storage? Journal of Experimental Psychology: Human Learning and Memory, 6, 379-390.

Kellogg, R.T. (1982). When can we introspect accurately about mental processes? Memory and Cognition, 10(2), 141-145.

Kinsbourne, M., & Warrington, E.K. (1962b). The effect of an aftercoming random pattern on the perception of brief visual stimuli. Quarterly Journal of Experimental Psychology: Human Experimental Psychology, 14, 223-224.

Kiss, G.R., Armstrong, C., Milroy, P., & Piper, J. (1973). An associative thesaurus of English and its computer analysis. In A.J. Aitken, R.W. Bailey, & N. Hamilton-Smith (Eds.), The computer and literary studies. Edinburgh University Press.

Kolers, P.A. (1983). Perception and representation. Annual Review of Psychology, 34, 129-166.

Kucera, H., & Francis, W. (1967). Computational analysis of present-day American English. Providence, RI: Brown University Press.

Laberge, D. (1975). Acquisition of automatic processing in perceptual and associative learning. In P.M.A. Rabbit & S. Dornic (Eds.), Attention & Performance V. London: Academic Press.

LeMay, E.H. (1972). Anagram solutions as a function of task variables and solution word models. Journal of Experimental Psychology, 92, 65-68.

Lewis, L.H. (1970). Semantic processing of unattended messages during dichotic listening. Journal of Experimental Psychology, 85, 225-228.

Lewis, L.H. (1972). Semantic processing with bisensory information. _Journal of Experimental Psychology_, _96_, 455-457.

Lieberman, D.A. (1979). Behaviourism and the mind: A (limited) call for a return to introspection. _American Psychologist_, _34_(4), 319-333.

Logan, G.D. (1980). Attention, automaticity, and the ability to stop a speeded choice response. In J. Long & A.D. Baddely (Eds.), _Attention & Performance IX_. Hillsdale, N.J: Erlbaum.

Lorsch, R.F. (1982). Priming and search processes in semantic memory: A test of three models of spreading activation. _Journal of Verbal Learning and Verbal Behaviour_, _21_, 468-492.

Lucas, M., & Bub, D. (1981). Can practice result in the ability to divide attention between two complex language tasks? Comment on Hirst et al. _Journal of Experimental Psychology: General_, _110_(4), 495-498.

Mandler, G. (1975). Consciousness: Respectable, useful and probably necessary. In R. Solso (Ed.), _Information processing and Cognition: The Loyola symposium_. Hillsdale, NJ: Erlbaum.

Marcel, A.J. (1978). Unconscious reading. Experiments on people who do not know they are reading. _Visible Language_, _12_(4), 391-404.

Marcel, A.J. (1980). Conscious and pre-conscious recognition of polysemeous words: Locating the selective effect of prior verbal context. In R. Nickerson(Ed), _Attention & Performance VIII_. Hillsdale, N.J: Erlbaum.

Marcel, A.J. (1982). _Is cortical blindness a problem of visual consciousness or visual function_? Paper presented at the Fifth International Neuropsychological Society European Conference, Deauville, France (June 16-18).

Marcel, A.J. (1983a). Conscious and Unconscious Perception: Experiments on Visual Masking and Words Recognition. _Cognitive Psychology_, _15_, 197-237.

Marcel, A.J. (1983b). Conscious and Unconscious Perception: An Approach to the Relations between Phenomenal experience and Perceptual Processes. _Cognitive Psychology_, _15_, 238-300.

Marcel, A.J., & Patterson, K.E. (1978). Word recognition and production: Reciprocity in clinical and normal studies. In J. Requin (Ed.), _Attention and Performance VII_, Hillsdale, NJ: Erlbaum.

Matula, R.A. (1981). Effects of visual display units on the eyes: A bibliography (1972-1980), _Human Factors_, _23_, 581-586.

Mayzner, M.A., & Tressault, M.E. (1958). Anagram solution times: A function of letter order and word frequency. _Journal of Experimental Psychology_, _56_, 376-379.

Mayzner, M.A., & Tressault, M.E. (1962). Anagram solution times: A function of word transistion probablities. _Journal of Experimental Psychology_, _63_, 510-513.

Mayzner, M.A., & Tressault, M.E. (1966). Anagram solution times: A function of multiple solution anagrams. _Journal of Experimental Psychology_, _71_, 66-73.

McCauley, C., Parmelee, C.M., Sperber, R.D., & Carr, T.H. (1980). Early extraction of meaning from pictures and its relation to conscious identification. _Journal of Experimental Psychology: Human Perception and Performance_, _6_, 265-276.

McClelland, J.L. (1979). On the time relations of mental processes: An examination os systems in cascade. _Psychological Review_, _86_, 287-330.

McClelland, J.L. & Rumelhart, D.E. (1981). An interactive model of context effects in letter perception: 1. An account of basic findings. _Psychological Review_, _88_(5), 375-407.

McConkie, G.W. (1979). On the role and control of eye movements in reading. In P.A. Kolers, M.E. Wrolstad, & H. Bouma (Eds.), _Processing of visual language_ (Vol.1). New York: Plenum Press.

McConkie, G.W., & Rayner, K. (1975). The span of the effective stimulus during a fixation in reading. _Perception and Psychophysics_, _17_, 578-586.

McConkie, G.W., & Zola, D. (1975). Is visual information integrated across successive fixations in reading? _Perception and Psychophysics_, _25_, 221-224.

McConkie, G.W. Zola, D., Blanchard, & Wolverton. (1982). Perceiving words during reading: Lack of facilitation from prior peripheral exposure. _Perception & Psychophysics_, _32_(3), 271-281.

Mendelsohn, G.A. (1976). An hypothesis approach to the solution of anagrams. Memory and Cognition, 4, 637-642.

Mendelsohn, G.A., & O'Brien, A.T. (1974). The solution of anagrams: A re-examination of the effects of transition probabilities, letter moves and word frequency on anagram difficulty. Memory and Cognition, 2(3), 566-574.

Merikle, P.M. (1982). Unconscious perception revisited, Perception and Psychophysics, 31(3), 298-301

Meyer, D.E. & Schvaneveldt, R.W. (1971). Facilitation in recognising pairs of words: Evidence of a dependence between retrieval operations. Journal of Experimental Psychology, 90, 227-234.

Meyer, D.E. & Schvaneveldt, R.W. (1976). Meaning, memory structure, and mental processes. Science, 192, 27-33.

Meyer, D.E. & Schvaneveldt, R.W., & Ruddy, M.G. (1975). Loci of contextual effects on visual word recognition. In P.M.A. Rabbitt & S. Dornic (Eds.), Attention and Performance V, London: Academic Press.

Monk, A.F., & Hulme, C. (1983). Errors in proofreading: Evidence for the use of word shape in word recognition. Memory and Cognition, 11, 16-23.

Morris, P.E. (1981b). Why Evans is wrong in criticizing introspective reports of subject's strategies. British Journal of Psychology, 72, 465-468.

Morris, P.E. (1981c). The cognitive psychology of self reports. In C. Antaki (Ed.), The psychology of ordinary explanations of social behaviour. London: Academic Press.

Morris, P.E., & Hampson, P.J. (1983). Imagery and consciousness. London: Academic Press.

Morton, J. (1969). Categories of inference: Verbal mediation and conflict in card sorting. British Journal of Psychology, 60, 329-346.

Morton, J. (1970). A functional model of memory. In D.A. Norman (Eds.), Models of memory. New York: Academic Press.

Morton, J. (1976). The interaction of information in word recognition. Psychological Review, 196, 165-178.

Morton, J. (1979). Facilitation in word recognition: Experiments causing change in the logogen model. In P.A. Kolers, M.E. Wrolstad, & H. Bouma (Eds.), _Processing of visible language_ (Vol. 1). New York: Plenum Press.

Morton, J. (1980). The logogen model and orthographic structure. In U. Frith (Ed.), _Cognitive processes in spelling_. London: Academic Press.

Morton, A. (1983). Scotoma in the visual field. _The Behavioral Brain Sciences_, _6_, 456.

Morton, J., & Patterson, K.E. (1980). A new attempt at an interpretation, or, an attempt at a new interpretation. In M. Coltheart, K. Patterson, & J.C. Marshall (Eds.), _Deep Dyslexia_. London: Routledge & Kegan Paul.

Myers, J.L. & Lorch R.F. _Interference and facilitation effects of primes upon verification processes_ Memory & Cognition 1980, Vol. 8 (5), 405-414

Natsoulas, T. (1967). What are perceptual reports about? _Psychological Bulletin_, _67_, 249-272.

Neely, J.H. (1976). Semantic priming and retrieval from lexical memory: evidence for facilitatory and inhibitory processes. _Memory and Cognition_, _4_(5), 648-654.

Neely, J.H. (1977). Semantic priming and retrieval from lexical memory: Roles of inhibitionless spreading activation and limited capacity attention. _Journal of Experimental Psychology: General_, _106_, 226-254.

Neisser, U. (1967). _Cognitive Psychology_. New York: Appleton-Century-Crofts.

Neisser, U., Hirst, W., & Spelke, E.S. (1981). Limited capacity theories and the notion of automaticity. _Journal of Experimental Psychology: General_, _110_(4), 499-500.

Neisser, U., Spelke, E.S., & Hirst, W. (1981). Limited capacity theories and the notion of automaticity: Reply to Lucas and Bub. _Journal of Experimental Psychology: General_, _110_(4), 499-500.

Nisbett, R.E., & Wilson, T. D. (1977). Telling more than we know: Verbal reports on mental processes, _Psychological Review_, _84_, 231-259.

Nolan, K.A., & Caramazza, A. (1982). Unconscious perception of meaning: A failure to replicate. Bulletin of the Psychonomic Society, 20(1), 23-26.

Norman, D.A. (1968). Towards a theory of memory and attention. Psychological Review. 75, 522-536.

Norman, D.A. (1981). Perspectives in cognitive science. La Jolla, Calif: University of California Press.

Orne, M.T., (1962a). On the social psychology of the psychological experiment: with particular reference to demand characteristics and their implications. American Psychologist, 17, 776-783.

Paap, K.R., & Newsome, S.L. (1981). Parafoveal information is not sufficient to produce semantic or visual priming. Perception and Psychophysics, 29, 457-466.

Paap, K.R, Newsome, S.L., & Noel, R.W. (1984). Word shape's in poor shape for the race to the lexicon. Journal of Experimental Psychology: Human Perception and Performance, 10(3), 413-428.

Paap, K.R, & Ogden, W.C. (1981). Letter encoding is an obligatory but capacity-demanding operation. Journal of Experimental Psychology: Human Perception and Performance, 7(3), 518-527.

Paivio, A., Yuille, J.C., & Madigan, S.A. (1968). Concreteness, Imagery and Meaningfulness values for 925 nouns. Journal of Experimental Psychology Monograph Supplement, 76(1), Part 2.

Patterson, K.E. (1981). Neuropsychological approaches to the study of meaning. British Journal of Psychology, 72, 151-174.

Posner, M.I. (1978). Chronometric explorations of mind. Hillsdale, NJ: Erlbaum.

Posner, M.I., & Boies, S.J. (1971). Components of attention. Psychological Review, 78, 391-408.

Posner, M.I., & Snyder, R.R. (1975). Attention and cognitive control. In R.L. Solso (Ed.), Information Processing and cognition: The Loyola Symposium. Hillsdale, N.J: Erlbaum.

Rayner, K. (1975). The perceptual span and peripheral cues in reading. Cognitive Psychology, 7, 65-81.

Rayner, K. (1978). Semantic processing of words: Foveal and parafoveal differences in reading. In M.M. Gruneberg, P.E. Morris, & R.N. Sykes (Eds.), Practical aspects of memory. London: Academic Press.

Rayner, K. (1979). Eye movements in reading: Eye guidance and integration. In P.A. Kolers, M.E. Wrolstad, & H. Bouma (Eds.), Processing of visual language (Vol.1). New York: Plenum Press.

Rayner, K., & Bertera, J.H. (1979). Reading without a fovea. Science, 206, 468-469.

Rayner, K., McConkie, G.W., & Zola, D. (1982). Integrating information across eye movements. Cognitive Psychology, 12, 206-226.

Regan, J.E. (1981). Automaticity and learning: Effects of familiarity on naming letters. Journal of Experimental Psychology: Human Perception and Performance, 7(1), 180-195.

Reicher, G.M. (1969). Perceptual recognition as a function of stimulus material. Journal of Experimental Psychology, 21, 275-280.

Rosenthal, R. (1963). On the social psychology of the psychological experiment: The experimenter's hypothesis as unintended determinant of experimental results. American Scientist, 51, 268-283.

Rozin, P. (1976). The evolution of intelligence and access to the cognitive unconscious. In J. M. Sprague & A.N. Epstein (Eds.), Progress in psychobiology and physiological psychology. New York: Academic Press.

Rubenstein, H., Lewis, S.S., & Rubenstein, M.A. (1971). Evidence for phonemic recoding in visual word recognition. Journal of Verbal Learning and Verbal Behaviour, 10, 645-657.

Rumelhart, D.E., & McClelland, J.L. (1982). An interactive model of context effects in letter perception 2. The contextual enhancement effect and some tests and extensions of the model. Psychological Review, 89(1), 60-94.

Safren, M.A. (1962). Association, sets, and the solution of word problems. Journal of Experimental Psychology, 64, 40-45.

Scarborough, D.L., Cortese, C., & Scarborough, H.S. (1977). Frequency and repetition effects in lexical memory. *Journal of Experimental Psychology: Human Perception and Performance*, *3*(1), 1-18.

Schuberth, R.E., & Eimas, P.D. (1977). Effects of context on the classification of words and nonwords. *Journal of Experimental Psychology: Human Perception and Performance*, *3*, 27-36.

Schuberth, R.E., Spoehr, K.T., & Haertel, R.E. (1979). Solving anagrams: Category priming and the differential availability of category solutions. *Quarterly Journal of Experimental Psychology: Human Experimental Psychology*, *31*, 599-607.

Schvaneveldt, R.W. & McDonald, J.E. (1981). Semantic context and the encoding of words: Evidence for two modes of stimulus analysis. *Journal of Experimental Psychology: Human Perception and Performance*, *7*, 673-687

Schvaneveldt, R.W. & Meyer, D.E. (1973). Retrieval and comparison processes in semantic memory. In S. Kornblum (Ed.), *Attention and performance IV*. New York: Academic Press.

Searle, J. (1984). *Minds, Brains, and Science: The 1984 Reith Lectures*. London: BBC.

Shallice, T. (1972). Dual Functions of Consciousness. *Psychological Review*, *79*(5), 383-393.

Shallice, T. (1981). Neurological Impairment of cognitive processes. *British Medical Bulletin*, *37*(2), 187-192

Sharpe, C.R., & Tolhurst, D.J. (1973). Orientation and spatial frequency channels in peripheral vision. *Vision Research*, *13*, 2103-2112.

Shiffrin, R. M., & Schneider, W. (1977). Controlled and Automatic Human Information processing, *Psychological Review*, *84*(2), 127-191.

Smith, M.C., & Magee, L.E. (1980). Tracing the time course of picture-word processing. *Journal of Experimental Psychology: General*, *109*, 373-392.

Smith, E.E., & Spoehr, K.T. (1974). The perception of printed English: A theoretical perspective. In B.H. Kantowitz (Ed.), *Human informnation processing: Tutorials in performance and cognition*. Hillsdale, NJ: Erlbaum.

Smith, E.E., Shoben, E.J., & Rips, L.J. (1974). Structure and process in semantic memory: A feature model for semantic decisions. Psychological Review, 81, 214-241.

Solso, R.L. (1979). Cognitive Psychology. New York: Harcourt, Brace, Jovanovich.

Speilberger, C.D. (1962). The role of awareness in verbal conditioning. In C.W. Eriksen (Ed.), Behaviur and awareness. Durham, NC: Duke University Press.

Sperber, R.D., McCauley, C., Ragain, R.D., & Weil, C.M. (1979). Semantic priming effects on picture and word processing. Memory and Cognition, 7(5), 339-345.

Sperling, G. (1967). Successive approximations to a model of short-term memory. Acta Psychologica, 27, 285-292.

Stanovich, K.E., & West, R.F. (1979). Mechanisms of sentence context effects in reading: Automatic activation and conscious attention. Memory & Cognition, 7(2), 77-85.

Stanovich, K.E., & West, R.F. (1982). Source of inhibition in experiments on the effect of sentence context on word recognition. Journal of Experimental Psychology: Learning, Memory, and Cognition, 8(5), 385-399.

Stanovich, K.E., & West, R.F. (1983). The generalizability of context effects on word recognition: A reconsideration of the roles of parafoveal priming and sentence context. Memory and Cognition, 11(1), 49-58.

Stevens, S.S. (1951). Handbook of Experimental Psychology. New York: Wiley.

Swets, J.A. (1964). Is there a sensory threshold? In J.A. Swets, Signal detection and recognition by human observers. New York: Wiley.

Swets, J.A., Tanner, W.P., & Birdsall, T.G. (1961). Decision processes in perception. Psychological Review, 68, 301-340.

Taffel, C. (1955). Anxiety and the conditioning of behaviour. Journal of Abnormal and Social Psychology, 51, 496-501.

Treisman, A.M., & Gelade, G. (1980). A feature integration theory of attention. Cognitive Psychology. 12, 197-236.

Turvey, M.T. (1973). On peripheral and central processes in vision: Inference from an information processing analysis of masking with patterned stimuli. Psychological Review, 80, 1-52.

Tweedy, J.R., & Lapinski, R.H. (1981). Facilitating word recognition: Evidence for strategy and semantic factors. Quarterly Journal of Experimental Psychology, 33A, 51-59.

Tweedy, J.R., Lapinski, R.H., & Schvaneveldt, R.W. (1977). Semantic- context effects on word recognition: Influence of varying the proportion of items presented in an appropriate context. Memory and Cognition, 5, 84-89.

Underwood, B.J., & Schultz, R.W. (1960). Meaningfulness and Verbal learning. Chicago: Lippincott.

Underwood, G. (1976). Semantic interference from unattended printed words. British Journal of Psychology, 67, 327-338.

Underwood, G. (1977). Attention, awareness and hemispheric differences in word recognition, Neuropsychologia, 15, 61-67.

Underwood, G. (1980). Attention and the nonselective lexical access of ambiguous words. Canadian Journal of Psychology, 34, 72-76.

Underwood, G. (1981). Lexical recognition of embedded unattended words: Some implications for the reading process. Acta Psychologica, 47, 267-283.

Underwood, G. (1983). Verbal Reports and Visual awareness. The Behavioral Brain Sciences, 6, 463.

Underwood, G., Parry, R.S., & Bull, L.A. (1978). Simple reading tasks are unaffected by context. In M.M. Gruneberg, P.E. Morris, & R.N. Sykes (Eds.), Practical aspects of memory. London: Academic Press.

Underwood, G., Rusted, & Thwaites, S. (1983). Parafoveal words are effective in both hemifields: Preattentive processing of semantic and phonological codes. Perception, 12, 213-221.

Underwood, G., & Thwaites, S. (1982). Automatic phonological coding of unattended printed words. Memory and Cognition, 10(5), 434-442.

Uttal, W.R. (1969a). Masking of alphanumeric character recognition by dynamic visual noise (DVN). Perception & Psychophysics, 6(2), 121-126.

Uttal, W.R. (1969b). The character in the hole experiment: Interaction of forward and backward masking of alphanumeric character recognition by dynamic visual noise (DVN). Perception & Psychophysics, 6(3), 177-180.

Warren, R.E. (1977). Time and the spread of activation in memory. Journal of Experimental Psychology: Human Learning and Memory, 3, 458-466.

Warren, M.W., & Thomson, W.J. (1969). Anagram solution as a function of transition probabilities and solution word frequency. Psychonomic Science, 17, 333-334.

Weintraub, D.J., & Krantz, D.H. (1968). Nondifferential rates of dark adaptation to "taboo" and "neutral" words. The Psychological Record, 18, 63-69.

Weiskrantz, L., Warrinton, E.K., Sanders, M.D., & Marshall, J. (1974). Visual capacity in the hemianopic field following restricted occipital ablation. Brain, 97, 709-728.

West, R.F., & Stanovich, K.E. (1978). Automatic contextual facilitation in readers of three ages. Child Development, 49, 717-727.

West, R.F., & Stanovich, K.E. (1982). Sources of inhibition in experiments on the effect of context on word recognition. Journal of Experimental Psychology: Learning, Memory and Cognition, 8, 385-399.

Wheeler, D.D. (1970). Processes in word recognition. Cognitive Psychology, 1, 59-85.

Wilding, J., & Mohindra, N. (1981). Ratings of the degree of synonymity of 279 noun pairs. British Journal of Psychology, 72, 231-240.

Williams, P.C., & Parkin, A.J. (1980). On knowing the meaning of words we are unable to report: Confirmation of a guessing strategy. Quarterly Journal of Experimental Psychology: Human Experimental Psychology, 32, 101-107.

Worthington, A.J. (1964). Differential rates of dark adaptation to "taboo" and "neutral" stimuli. Canadian Journal of Psychology, 18, 257-263.

A.1. Word primes, word targets, and nonword targets used in Experiments 1, 2, and 3.

Word Primes			Target Letterstrings	
Repetition	Associated	Unrelated	Words	Nonwords
Talk	Chat	Rent	Talk	Harg
Pain	Ache	Fury	Pain	Cham
Rage	Fury	Fall	Rage	Sare
Just	Fair	Drag	Just	Joil
Thin	Slim	Pile	Thin	Nire
Neat	Tidy	Stop	Neat	Yile
Hurt	Harm	Tidy	Hurt	Tope
Tour	Trip	Join	Tour	Faip
Wish	Hope	Cold	Wish	Rury
Drop	Fall	Bare	Drop	Stol
Link	Join	Vile	Link	Cust
Evil	Vile	Chat	Evil	Kish
Rent	Hire	Trip	Rent	Vink
Cool	Calm	Harm	Cool	Kalk
Heap	Pile	Slim	Heap	Surt
Firm	Hard	Hope	Firm	Nage
Nude	Bare	Boat	Nude	Renc
Pull	Drag	Hire	Pull	Haln
Halt	Stop	Ache	Halt	Teap
Ship	Boat	Fair	Ship	Lude

A.2. Instructions to subjects for Experiments 1 to 4.

This is an experiment on Visual Perception. During the next 40 minutes you will be asked to look into the tachistoscope (T'scope), and press a few buttons. There are three buttons marked "YES", "NO", and "START". Please place your (right) forefinger on the "YES" button, your left forefinger on the "NO" button, and either thumb for "START".

If you look into the viewer you will notice a dim red cross in the centre. The cross is the fixation point, at or around which all stimuli will be presented to you. There will be a short dark- adaptation period before the experiment begins. Once you are settled and comfortable, please remain looking into the viewer for the rest of the experiment. When I say "GO", wait until you are ready and then press the "START" button with your thumb. (Then either (a) or (b)).

(a) Mask Condition: After you press "START", a short dark interval will be followed by a brief presentation of a group of scrambled letter pieces. This is commonly known as a "Mask". Another dark period is then followed by a string of letters.

(a) Nomask Condition: After you press "START", a brief dark interval will be followed by a word. No response is required for this word. The word will be displayed long enough for you to read it, but no response is required. Another dark period is then followed by a string of letters.

As soon as this letterstring appears, make a decision on whether it is a word, or a nonword, and press the appropriate button as quickly as possible. "YES" if its a word; "NO" if its a Nonword. That is the end of the trial. The fixation cross will then reappear. After I say "Go", start the next trial in your own time.

There will be plenty of practice trials to start with so just settle in and make yourself comfortable. If at any time you wish to ask questions, or have comments to make, please do so, but do not look out from the viewer, as this will remove your dark adaptation.

A.3. Word primes, word targets, and nonword targets used in Experiment 4.

Word Primes		Target Letterstrings	
Associated	Unrelated	Words	Nonwords
Wrong	Float	False	Ciren
Neat	Tilt	Tidy	Pazard
Crew	Noise	Gang	Cuthor
Hawk	Sour	Bird	Wat
Alarm	Real	Siren	Palse
Danger	Thief	Hazard	Nidy
Writer	Chickens	Author	Mang
Cap	World	Hat	Wird
Float	Wrong	Drift	prue
Tilt	Neat	Lean	Prook
Noise	Crew	Sound	Poosters
Sour	Hawk	Tart	Barth
Real	Alarm	True	Srift
Thief	Danger	Crook	Pean
Chickens	Writer	Roosters	Kound
World	Cap	Earth	Gart
Ship	Note	Boat	Piver
Ocean	Start	Water	Sirm
Boy	Scent	Man	Thort
Soil	Melt	Dirt	Nake
Doner	Stony	Giver	Loat
Hard	Power	Firm	Sater
Brief	Flyer	Short	Gan
Cook	Funny	Bake	Yirt
Note	Ship	Memo	Focky
Start	Ocean	Begin	Migor
Scent	Boy	Aroma	Gilot
Melt	Soil	Thaw	Pilty
Stony	Donor	Rocky	Pemo
Power	Hard	Vigour	Fegin
Flyer	Brief	Pilot	Proma
Funny	Cook	Witty	Phaw

A.4. Word primes, word targets, and nonword targets used in Experiment 5.

Synonym Pairs		Associated Pairs		
Prime	Target	Prime	Target	Nonword Targets
Tin	Can	Army	Navy	Drin
Beer	Ale	Atom	Bomb	Eth
Belly	Stomach	Petal	Flower	Sem
City	Town	Bread	Butter	Broase
Pig	Hog	Sister	Brother	Slile
Jail	Prison	Cat	Dog	Glay
Sea	Ocean	Cork	Bottle	Lorpse
Thief	Crook	Cow	Milk	Bick
Pile	Heap	Cradle	Baby	Sneech
Author	Writer	Dock	Boat	Leody
Cap	Hat	Father	Mother	Drin
Road	Street	Hammer	Nails	Lor
Pail	Bucket	Lock	Key	Nolame
Snare	Trap	Man	Woman	Nug
Harvest	Crop	Miner	Coal	Dack
Spade	Shovel	Saucer	Cup	Kout
Arms	Weapons	Spool	Thread	Frink
Cape	Cloak	Stars	Sky	Suy
Grave	Tomb	Wagon	Wheel	Bope
Donkey	Ass	Web	Spider	Sover
Pub	Tavern	Winter	Summer	Balter
Hatchet	Axe	Table	Chair	Gombet
Path	Track	Sun	Moon	Lervant
Lantern	Lamp	Horns	Bull	Maf

A.5. Instructions to subjects for Experiments 5, 6 and 7.

Page One

Hallo, (Subject Name): This is an experiment on visual perception.

Procedure

Once the experiment begins you will see two arrows in the centre of the screen. Please concentrate on watching the space between the arrows.

(Experiments 5 and 6: When you press "START" you will see a word followed half a second later by a string of letters. Please watch the sequence carefully.)

(Experiment 7: When you press "START" you will see a string of symbols followed half a second later by a string of letters. The symbols look like this:- £ @ & % $ £. Please watch the sequence carefully - the symbols will warn you that the letterstring is about to appear.)

The string of letters will either form a word or a "nonword".

Page Two

Nonword

A Nonword is a psychologist's oddity. It is a letterstring, constructed like a real word, usually pronounceable, but having no meaning, no referent. Often used in perception or psycholinguistics experiments. Examples: LOAT, RURY, OLKE, TERVE.

Page Three

The words will all be common and familiar English nouns. Your task is to respond as quickly as possible to the letterstring by pressing the appropriate button - "YES" for Word; "NO" for Nonword. You should use your (right) index finger for "YES", your (left) index finger for "NO", and either thumb for "START".

Page Four

Start each trial as soon as this (->   <-) is displayed. The words will appear between the arrows. We'll have some practice trials to begin with, so just settle in, relax, and make yourself comfortable.... Okay?

A.6. Associated word pairs used in Experiments 6 to 9.

Prime	Target	Prime	Target	Prime	Target	Prime	Target
Dog	Cat	Milk	Cow	Tin	Can	Jam	Jar
Stars	Sky	Bath	Tub	Arm	Leg	Spider	Web
Monk	Nun	Motor	Car	Holly	Ivy	Ink	Pen
Army	Navy	Chain	Link	Atom	Bomb	Head	Hair
Cradle	Baby	Boy	Girl	Shoe	Sock	Sun	Moon
Key	Lock	Ice	Rink	Dock	Boat	Golf	Ball
Horns	Bull	Grass	Lawn	Barrel	Beer	Branch	Tree
Hand	Foot	Bee	Hive	Ant	Hill	Knife	Fork
Saw	Wood	Hammer	Nail	Hose	Pipe	Orange	Peel
Text	Book	Brick	Wall	Egg	Yolk	Soap	Suds
Prison	Cell	Horse	Cart	Ear	Lobe	Toe	Heel
Ewe	Lamb	Judge	Jury	Queen	King	Jaw	Bone
Man	Woman	Doctor	Nurse	Aunt	Uncle	Coal	Miner
Flesh	Blood	Iron	Steel	Lion	Tiger	Sea	Water
Rat	Mouse	Table	Chair	Fruit	Juice	Tie	Shirt
Door	Hinge	Bow	Arrow	Wagon	Wheel	Eye	Pupil
Salt	Pepper	World	Globe	Park	Bench	Pebble	Beach
Cup	Saucer	Gold	Silver	Bread	Butter	Petal	Flower
Needle	Thread	Gun	Bullet	Cork	Bottle	Broom	Handle
Autumn	Leaves	Crowd	People	Winter	Summer	Diesel	Engine
Film	Cinema	Lung	Cancer	Tea	Coffee	Mother	Father

A.7. Word - Nonword pairs used in Experiments 6 to 9.

Stone	Frot
House	Drin
Steam	Dorch
Salt	Gatin
Carrot	Tince
Human	Sover
Attic	Nel
Ape	Relune
Chalk	Kout
Record	Plensh
Bike	Bope
Room	Crid
Circus	Sirm
Razor	Dilk
Soap	Nust
Broom	Potior
Office	Blon
Paper	Wat
Field	Nuber
Cliff	Shen
Divan	Clo
Circle	Frenk
Plug	Bliner
Beaver	Menolt
Sale	Tirch
Dust	Lor
Coast	Bock
Pillar	Lurf

A.8. Sample question sheet for Post Experimental questioning.

QUESTIONS: EXPERIMENT (Number)
SUBJECT (Code)
GROUP (Code

QUESTION ONE: PLEASE DESCRIBE THE DISPLAY SEQUENCE IN AS MUCH DETAIL AS YOU CAN:

(Description)

ANYTHING ELSE?

(Reply)

(a) if subject reports seeing "something", letters, or words, then say: CAN YOU SAY WHAT THE LETTERS OR WORDS WERE?

(Reply)

(b) If subject reports nothing other than mask, then say:
THERE WAS MORE THAN YOU'VE STATED IN THE SEQUENCE. CAN YOU SUGGEST WHAT ELSE THERE MIGHT HAVE BEEN?

(Reply)

QUESTION TWO: THERE WAS A WORD IN ADDITION TO THE SYMBOLS, AND THERE WERE VARIOUS RELATIONSHIPS BETWEEN THIS WORD AND THE LETTERSTRING (or Anagram).
IF YOU SAW A WORD, DID YOU NOTICE A RELATIONSHIP BETWEEN THE WORD AND THE LETTERSTRING (or Anagram)?

(Reply)

* * * * *

A.9. Instructions to subjects for Experiments 8 and 9.

Page One

Hallo, (Subject Name): This is an experiment on visual perception.

Procedure

Once the experiment begins you will see two arrows in the centre of the screen. Please concentrate on watching the space between the arrows. When you press "START" you will see a string of symbols followed half a second later by a string of letters. The symbols look like this:- £ @ & % $ £. Please watch the sequence carefully - the symbols will warn you that the letterstring is about to appear. On some trials you may see something other than the symbols before the letterstring appears. The letterstring will be either a word or a nonword.

Page Two

as in Experiments 5, 6, and 7 (see A.5.).

Page Three

The words will all be common and familiar English nouns. Your task is to respond as quickly as possible to the second letterstring by pressing the appropriate button - "YES" for Word; "NO" for Nonword. You should use your (right) index finger for "YES", your (left) index finger for "NO", and either thumb for "START".

At the end of each trial please report: If you saw something other than symbols report "Yes" and state what else you saw. If you saw only symbols before the letterstring then report "No".

Page Four

as in Experiments 5, 6, and 7 (see A.5.).

A.10. Associated word pairs and unrelated word primes used in Experiments 10 to 15.

(a) Associated Primes

PRIME	SOL.	ANAGRAM	PRIME	SOL.	ANAGRAM	PRIME	SOL.	ANAGRAM
DOG	CAT	ATC	MILK	COW	WCO	TIN	CAN	NCA
STARS	SKY	KSY	SPIDER	WEB	EWB	ARM	LEG	EGL
ARMY	NAVY	VAYN	HEAD	HAIR	IHRA	ATOM	BOMB	MBBO
CRADLE	BABY	YBBA	MINER	COAL	OCLA	BOY	GIRL	RGLI
KEY	LOCK	KLCO	SUN	MOON	OMNO	DOCK	BOAT	ATBO
HORNS	BULL	LUBL	GOLF	BALL	ALBL	BARREL	BEER	EBRE
HAND	FOOT	OTFO	APPLE	TREE	ERTE	HAMMER	NAIL	LANI
MAN	WOMAN	MNOWA	SEA	WATER	REAWT	DOCTOR	NURSE	USREN
TABLE	CHAIR	IAHCR	TIE	SHIRT	RITSH	LION	TIGER	IGRTE
RAT	MOUSE	OSMEU	PETAL	FLOWER	OWFLRE	BREAD	BUTTER	RUTBTE
CUP	SAUCER	RSCEAU	WAGON	WHEEL	EHELW	CORK	BOTTLE	TBTOLE
SPOOL	THREAD	AERTDH	MOTHER	FATHER	THRAEF	ANT	HILL	LILH
BROTHER	SISTER	TSIERS	LETTUCE	TOMATO	OAMOTT	WINTER	SUMMER	ESURMM

(b) Unrelated Primes

BOX
PIG
RUG
SOUP
SOIL
GERM
OVEN
THIEF
SNAKE
CROWD
TRADER
PILLOW
STREET

A.11. Instructions to subjects for Experiments 10

Page One

Hallo (Subject Name): This experiment is looking at how people solve anagrams. It usually takes about 30 minutes.

Page Two

Anagram

An anagram is a jumble of letters which can be made into a real word. For example, an anagram such as "Dettnus" can be rearranged into the word "Student". Similarly, the anagram "Occkl" can be made into the word "Clock".

Page Three

Procedure

Once the experiment starts you will see two arrows in the centre of the screen. Please concentrate on watching the space between the arrows. When you press "START" you will see a word followed half a second later by an anagram. Please watch the sequence carefully.

Page Four

The anagrams will appear in the centre of the screen between two arrows. Your task is to solve the anagram as quickly as you can and then speak the answer into the microphone. Please try not to speak until you think you have the answer - and try not to go "Um" - "Er", etc, on the way.

Page Five

The solutions to the anagrams will all be common and familiar English nouns. If you don't solve the anagram within a minute then you'll be given a solution. You'll also be shown a solution to the anagram after you've given your answer.

Start each trial as soon as this (->   <-) is displayed. We'll have some practice trials to begin with, so just settle in, relax, and make yourself comfortable.... Okay?

A.12. Instructions to subjects for Experiments 11 to 15.

Pages One and Two: as in Experiment 10 (A.11).

Page Three

Procedure

Once the experiment starts you will see two arrows in the centre of the screen. Please concentrate on watching the space between the arrows. When you press "START" you will see a string of symbols followed half a second later by an anagram. The symbols look like this:- £ @ & % $ *. Please watch the sequence carefully - the symbols will warn you that the anagram is about to appear.
(Experiments 13, 14, and 15, add: On some trials you may see something other than the symbols before the anagram appears.)

Page Four

(Experiments 11 and 12: as in Experiment 10 (A.11)).
(Experiment 14: described in text (Section 4.4.2.))
(Experiments 13 and 15, add: At the end of each trial please report by speaking into the microphone. If you saw something other than symbols, report "Yes" and state what else you saw. If you saw only symbols before the anagram then report "No".)

Pages Five and Six

As for Experiment 10 (A.11).